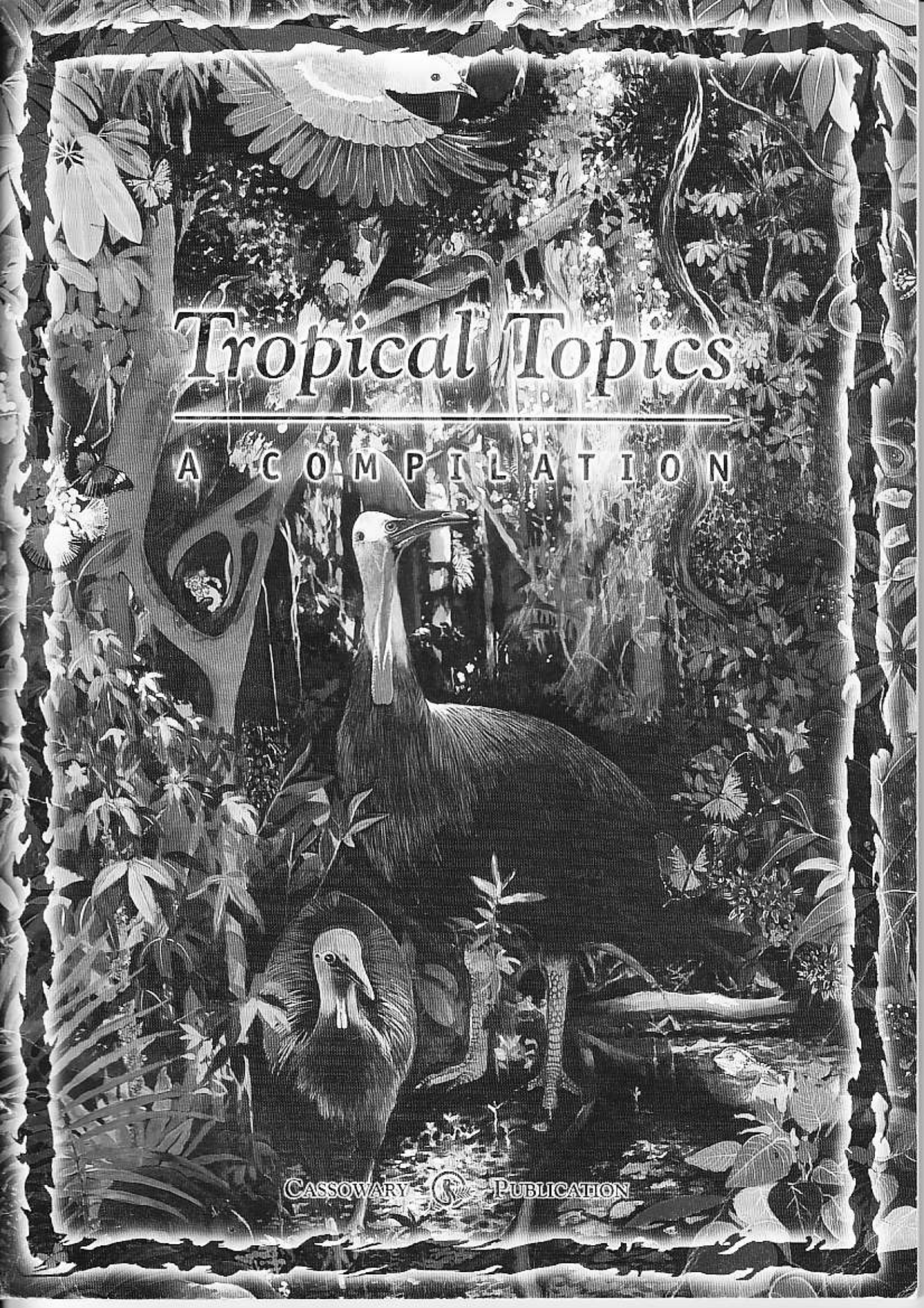
Tropical Topics
A COMPILATION
CASSOWARY PUBLICATION

Tropical Topics

a compilation
by Stella Martin

CASSOWARY PUBLICATION

QUEENSLAND GOVERNMENT
Department of Environment

WET TROPICS
MANAGEMENT AUTHORITY

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For information on how to obtain further copies of these booklets (wholesale or retail) contact the Wet Tropics Management Authority on (07) 4052 0555.

The cover shows sections of a mural painted by Ruth Berry for the Barron Falls lookout in Barron Gorge National Park. Photo: Yon Ivanovic

Contents

Introduction

Welcome to *Tropical Topics*, the booklet. *Tropical Topics* began life in 1992 as a newsletter for the tourism industry. It was a response to requests from participants in a series of training courses in marine and rainforest biology for tour operators, funded by the Great Barrier Reef Marine Park Authority and the Wet Tropics Management Authority, which were held in 1991 and 1992. These participants had expressed a need for ongoing information support and a regular newsletter was thought to be the most effective means of meeting that need.

Alternating between issues devoted to information on the Wet Tropics (printed in green), and issues devoted to the Great Barrier Reef (in blue), a large proportion of each newsletter was taken up with an in-depth look at one particular theme.

Over the years, as new staff have arrived to take up jobs in the tourism industry and teachers and others have begun to take an interest in the newsletters, there has been a constant demand for back issues of *Tropical Topics*. The original copies, however, ran out long ago so the Wet Tropics Management Authority decided to fund a compilation of the theme-based material from the first 12 issues devoted to Wet Tropics themes.

This booklet is the result. In adapting the original material, some revision and rewriting has been done to update it and a few layout changes have been necessary. The 12 newsletters have become 11 chapters (material in the Wet Tropics webs chapter was originally split between two issues) and the double-page spreads, which occupied the middle of each newsletter, have become the second and third pages of most chapters — depending on how central they are to the theme. (Some issues contained two double-page spreads.) The final page of each chapter is made up of three short sections, the *Facts and stats* column, the *Bookshelf* section, which gives sources of further information, and the *Tourist talk* box in which 10 key words relevant to the theme of the chapter are translated into German and Japanese to assist those tour operators who deal with visitors from these countries.

This booklet does not cover all tropical topics. However, it provides in-depth information on a range of subjects which are likely to appeal to most readers with an interest in the Wet Tropics. We hope you enjoy it.

The Gondwana connection

A living museum

Australian rainforests have long been considered poor cousins of rainforests in other parts of the world. The 'jungles' of Africa, Asia and South America conjure up romantic visions of exotic paradise and Tarzan movies. So much so that we are constantly trying to emulate them by landscaping our gardens and resorts with introduced foliage. (Which in many cases has resulted in the invasion of our native forests by runaway exotics.)

What respect we have held for our native flora in the past has generally been reserved for the distinctly Australian flora of the drier parts of the continent; our famous wattles, eucalypts, banksias and grevilleas. Most scientists believe that these plants originated from the ancient stock of Gondwana, the living descendants of which can be found in the Wet Tropics, as well as in drier Australia.

Gondwana — a supercontinent which existed hundreds of millions of years ago — comprised the southern continents as well as the Indian subcontinent. (The northern continents were joined in a similar landmass called Laurasia.)

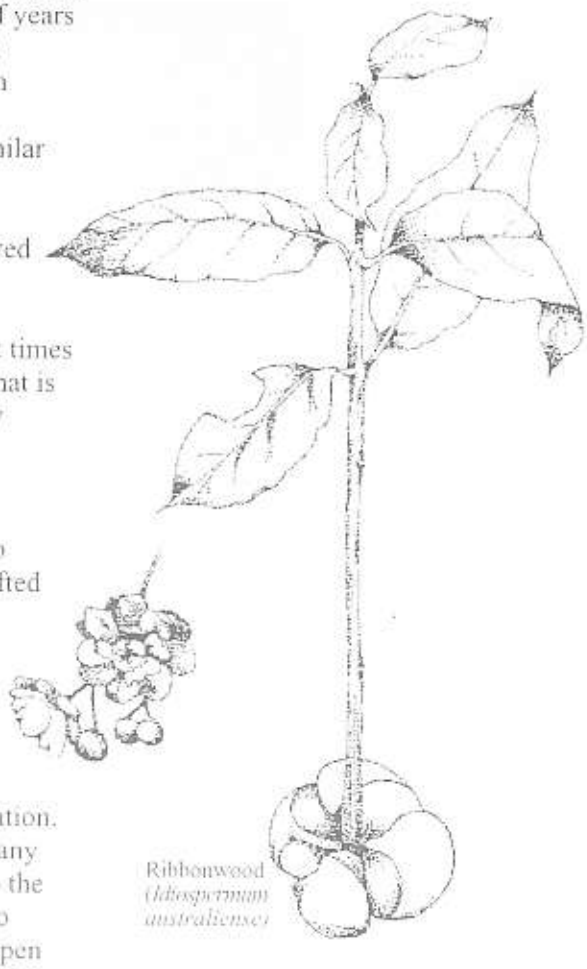
For millions of years life evolved across these supercontinents. Dinosaurs came and went and flowering plants developed. At times much of the land (including what is now Australia) was covered by rainforest.

About 180 million years ago Gondwana started to break into continents which gradually drifted apart. Australia was the last continent to break away, finally separating about 45 million years ago.

For about 30 million years Australia's life evolved in isolation. As the climate became drier many species died. Others adapted to the drier conditions and survived to colonise the vast areas of dry open forests, woodlands, grasslands and deserts which cover much of the continent today. Only the mountainous regions of the east coast remained constantly moist. It is here that the last remaining refuges of Australia's ancient rainforests survive, with many species little changed since the evolution of the first flowering plants.

Some plants such as ribbonwood (*Idiospermum australiense*) from Cape Tribulation have changed little. They appear today much as they did millions of years ago.

More primitive flowering plants are found in the Wet Tropics than anywhere else on earth.



Ribbonwood (*Idiospermum australiense*)

What's so special about the Wet Tropics?

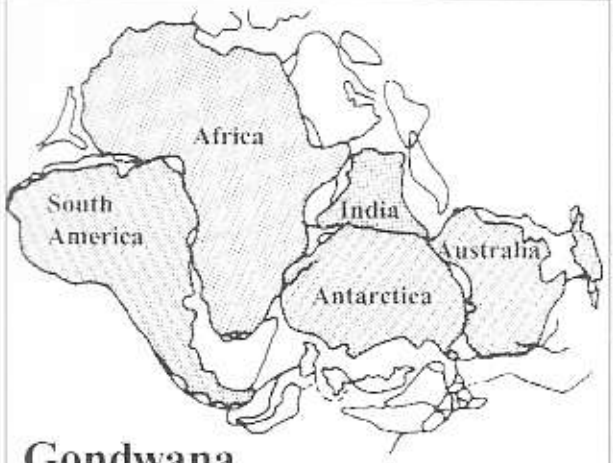
To be selected for World Heritage listing, an area must satisfy at least one of the following criteria. It must represent:

- a major evolutionary stage of the earth;
- a continuing process of geology, evolution, or man-and-environment;
- natural beauty; or
- a habitat that shelters threatened plants and animals.

The Wet Tropics satisfies all four!

This chapter will provide an insight into how the Wet Tropics represents a major evolutionary stage of the earth, and why it could have gained World Heritage listing on this basis alone!

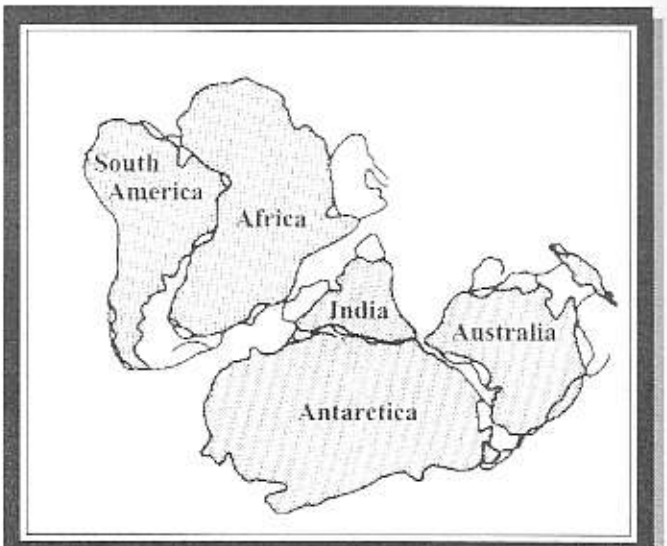
The Gondwana connection



Gondwana

The land masses of the world were once joined into a super-continent called Pangaea. This separated into two smaller land masses, Laurasia in the north and Gondwana in the south. Australia was part of Gondwana.

With a family tree dating back at least 20 million years, **musky rat-kangaroos** are considered the most primitive of living kangaroos. Four million years ago, their west Victorian relatives died out, leaving them as the sole survivors of the genus *Hypsiprimnodon*.

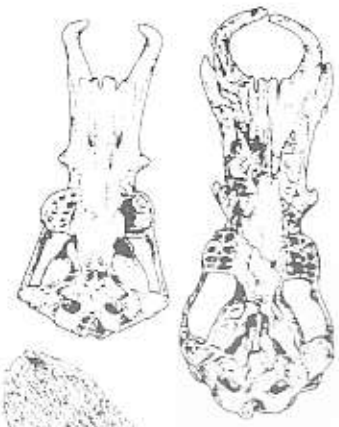


180 million years ago Gondwana started to break into continents which gradually drifted apart. Australia broke away about 45 million years ago.

Until recently, north Australian rainforests were thought to have invaded from Asia when the continental plates collided. More recent theories suggest that Australian rainforests are largely inherited from the ancient stock of Gondwana. This is particularly true of upland and southern forests, while lowland forests have mixed Asian and Gondwanic origins with refugial areas, such as Noah Creek in the Daintree, where Gondwanic plants predominate.

Flowers and seedling of ribbonwood (Idiospermum australiense)

Ribbonwood (*Idiospermum australiense*) is a rare and primitive flowering plant, found only in the Wet Tropics World Heritage Area. Thirteen of the nineteen families of primitive flowering plants occur in this area.



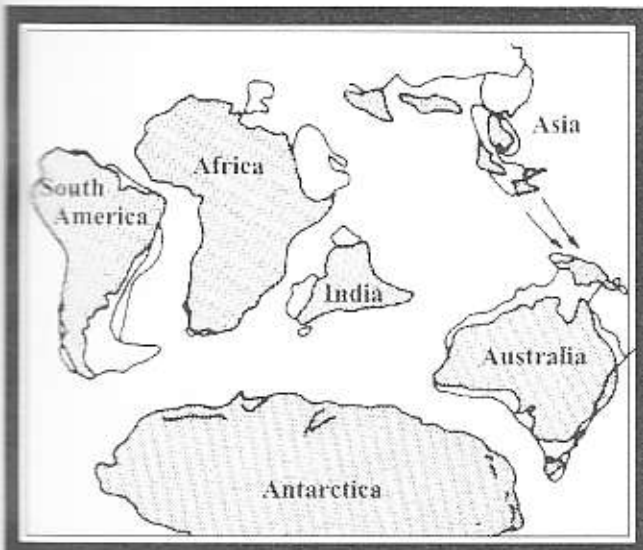
Compare the skull of a modern **platypus** (left) with the 15 to 20-million-year-old fossilised skull (right) of a platypus ancestor found at Riversleigh Station, north-west Queensland.

A giant platypus ancestor (known from a 110-million-year-old fossilised jaw from Lightning Ridge, NSW) was Australia's oldest mammal, and possibly the largest mammal in the world at that time!

Bull oak seedling

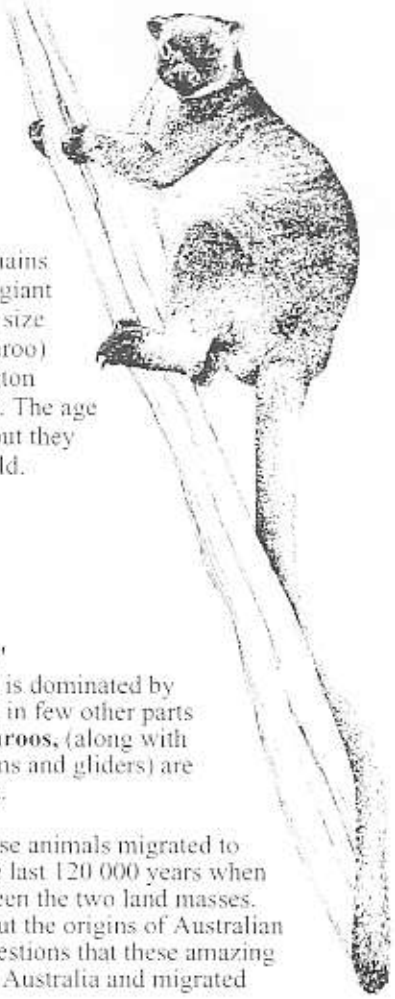
Millions of years ago rainforest covered much of Australia. As the climate began to change, many species of the Proteaceae family (including grevilleas, banksias and acacias) and the Myrtaceae family (eucalypts and bottlebrushes) began to adapt to the drier conditions. These now dominate the landscape and are distinctly Australian.

Ancestors of these plants still exist in the Wet Tropics. The **bull oak** (Proteaceae family) is one such plant.



Australia slowly moved northwards, completely isolated from other land masses. About 15-20 million years ago it collided with the Asian plate. Some plants and animals were able to move between the two continents.

Logrunners live only in rainforests. When they search for food, they lean back on their tails and toss leaf-litter sideways. Because of this odd habit, they have distinctive leg bones. Small, fossilised, logrunner bones have been found at semi-arid Riversleigh Station, along with the fossilised remains of many other rainforest ancestors.

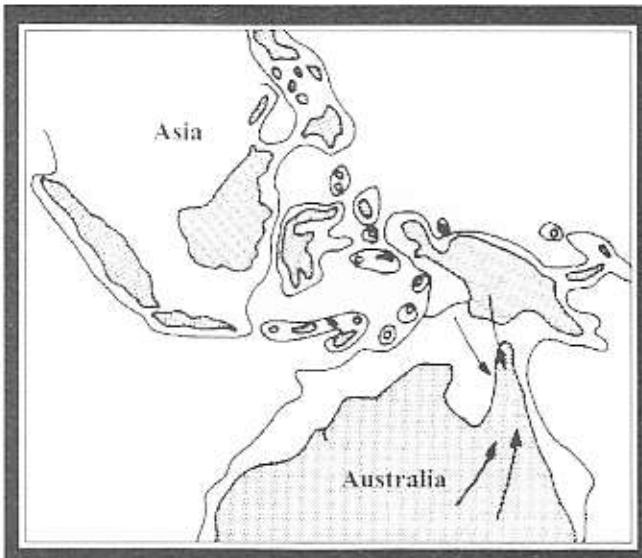


In 1982, the fossilised remains of what is thought to be a giant **tree-kangaroo** (about the size of a present day red kangaroo) were found in the Wellington Caves, New South Wales. The age of the bones is uncertain but they are at least 50 000 years old.

'Where do I come from?'
Australian mammal fauna is dominated by marsupials, a group found in few other parts of the world. **Tree-kangaroos,** (along with cuscuses and some possums and gliders) are also found in New Guinea.

Some theories suggest these animals migrated to Australia some time in the last 120 000 years when land bridges existed between the two land masses. Like the new theories about the origins of Australian rainforests, there are suggestions that these amazing animals also originated in Australia and migrated north.

Perhaps future fossil finds will hold the answer.



At times during the last 120 000 years, sea water became bound in ice. This caused lower sea levels and the gap between Australia and Asia became narrower. More species crossed over.

Facts and stats

on the Wet Tropics

Having been around for more than 100 million years, rainforests of the Wet Tropics World Heritage Area are the oldest, continuously surviving rainforests on earth.

Conifers and cycads of the Wet Tropics are living remnants from the time, 200 million years ago, when dinosaurs roamed the earth.

The World Heritage Area covers nearly 900 000ha, extending more than 400km between Cooktown and Townsville. It covers only 0.1 percent of Australia's total land mass.

The boundary of the Wet Tropics World Heritage Area has been estimated at about 3000km long.

About 300 000 people live in or within 50km of the Wet Tropics World Heritage Area.

The Wet Tropics currently receives about 3.4 million visits per year.

Bookshelf

The Greening of Gondwana
The 400 million Year Story of Australia's Plants
Mary E. White
Reed Books Pty Ltd (1986)

This book gives a thorough account of theories and fossil evidence of the evolution of Australia's flora. Written in chronological order, it may be too technical for some readers. Recommended to anyone with an interest in botany.

After the Greening
The Browning of Australia
Mary E. White
Kangaroo Press Pty Ltd (1994)

This four-part follow-up to The Greening of Gondwana deals with the breakup of Gondwana (Rifting), changes as Australia moved north (Drifting), effects of the Ice Ages (Drying) and finally the impact of European settlement (Unbalancing the Biota).

Riversleigh
The Story of Animals in Ancient Rainforests of Inland Australia.
Archer, Hand and Godthelp
Reed Books Pty Ltd (1991)

The amazing fossil 'goldmine' of Riversleigh Station makes fascinating reading for anyone. This book is written in a reader-friendly style with the enthusiasm of its authors showing through. However, a little over-enthusiasm in some areas (especially relating to flora) has led to errors. Nevertheless an interesting book .

Greater Daintree
World Heritage Tropical Rainforest at Risk.
Gregg Borschmann
Australian Conservation Foundation (1984)

The ACF published this book to promote the conservation values of the Daintree area prior to the Wet Tropics World Heritage listing. The book covers the political and natural history of the area. Unfortunately out of print, the book is well worth reading. Most local libraries should have a copy.

Wet Tropics in Profile
A reference guide to the Wet Tropics of Queensland World Heritage Area

Cassowary Publications (1996)

This booklet looks at World Heritage listing, the area and its special qualities, maintaining the Area's Heritage values and the Wet Tropics experience. A wealth of information.

Protection Through Partnerships
Policies for implementation of the Wet Tropics Plan
Wet Tropics Management Authority (1997)

This booklet deals with management processes, conservation and enjoyment of the Wet Tropics.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
World Heritage	Welterbschaft	sekai isan	世界遺産
continent	Kontinent	tairiku	大陸
rainforest	Regenwald	nettai u rin	熱帯雨林
dinosaur	Dinosaurier	kiyoryiu	恐竜
prehistoric	vorgeschichtlich	yuushiizen no	有史以前の
fossil	Fossil	kaseki	化石
ancient	alt	kodai no	古代の
primitive	primitiv	genshiteki na	原始的な
refuge	Zuflucht	hogo	保護
modern	modern	gendai no	現代の

Light in the rainforest

The solar panel canopy

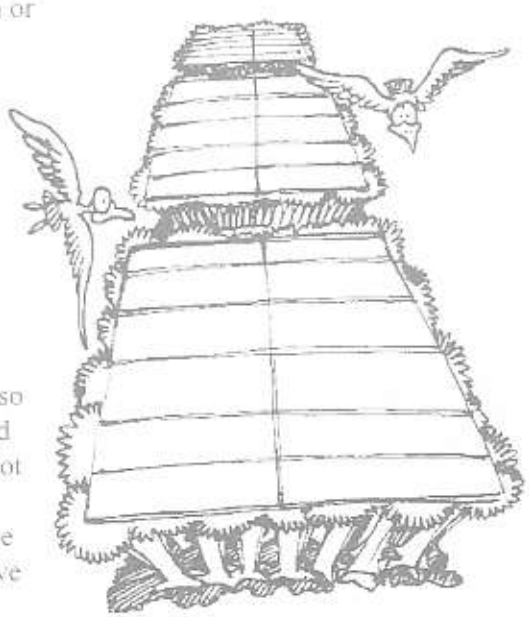
When we look down from an aeroplane on to the rainforest canopy we see a green roof — an almost solid mass of vegetation obscuring the ground below. What we are seeing are billions of leaves feeding. They are gorging on sunlight.

Animals eat other organisms, living or dead — a pre-prepared meal of nutrients. Plants, on the other hand, make their own food. They are the only living things that can capture energy from the sun and use it (through the process of photosynthesis) to produce sugars and other materials from which they build their own structures. Each leaf is a solar cell. The canopy is a vast solar panel.

The architecture of the forest is determined by a hunger for sunlight. There is fierce competition for this vital energy. Stretching high on tall, straight trunks, trees don't waste energy on producing branches until they reach the canopy and are able to compete successfully with their neighbours for available light. Trunks can be branchless to heights of 30m or more. On the other hand, the same trees, grown in full light — for example in a park or garden without competition from neighbours — will branch early in life and grow into shorter, bushy trees with completely different shapes.

The canopy is an interlocking network of sun-hungry leaves. It is so efficient that only between three and 15 percent of sunlight penetrates. Not all of the light is caught by the topmost leaves. Studies of mangrove (Rhizophoraceae family) forests have shown that leaves at the top of the canopy tend to be inclined so that they are not fully exposed to the sun. This probably prevents them from being damaged by the intensity of the tropical sun. (Leaves held up artificially to receive the full force of the sun were recorded to be 10deg. hotter than those at their natural, inclined, angle.) This arrangement also allows sunlight to be shared by leaves lower in the canopy. There the leaves, unlike those at the top, grow horizontally and can capture all the rays reaching them.

Researchers also discovered that, like the best solar panels, leaves move into the most efficient positions; leaf angles in these mangrove trees alter with changes in light between wet (cloudy) and dry (sunny) seasons.



Diversity in the sun

Sunlight is food. Without it few plants can live. The abundance of sunlight in the tropics produces more living plant material per hectare than anywhere else on the planet.

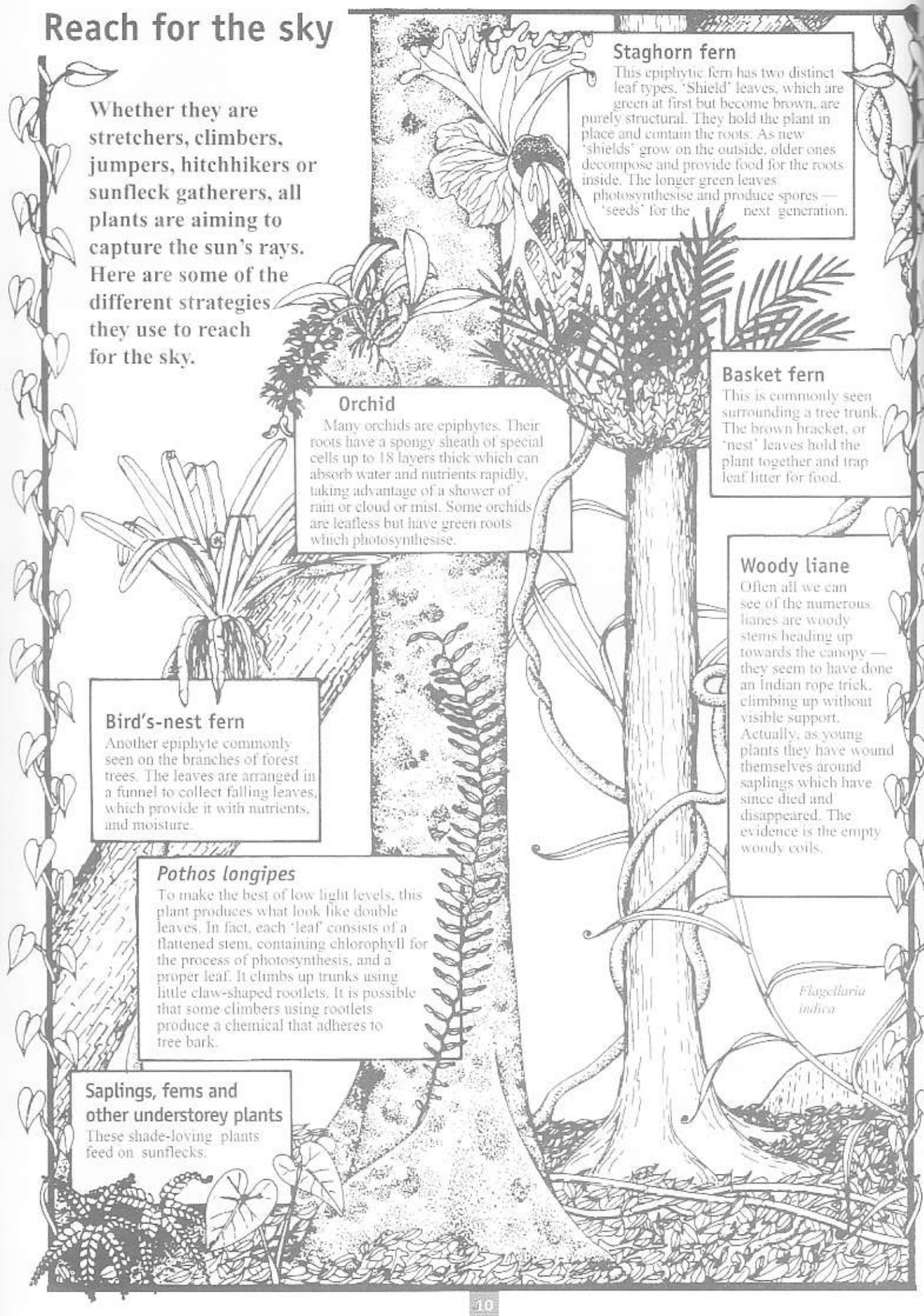
Ideal growing conditions have also produced one of the most diverse ecosystems on Earth (it is possible to find 120 tree species per hectare in Queensland's tropical forests compared with only 30 per hectare in temperate forests). Much scientific research has been done in an attempt to understand what produces such diversity. One theory is that different gaps in the forest canopy, producing different amounts of light are responsible.

The forest may need some disturbance but one thing is certain; human impact on tropical forests does nothing to maintain diversity. Clearing affects the nutrient balance (by removing trees, increasing soil erosion, fires, etc.) as well as the ability of the forest to regrow (by crushing saplings and compacting soil). Not least, these large gaps encourage growth of a limited number of hardy, light-loving species such as lawyer cane and stinging trees.

Research has shown that full regeneration of a forest can take 800 years — even longer if the disturbance is more severe. With this in mind we can be thankful that the forests of the Australian Wet Tropics are now protected. The long process of regeneration can begin.

Reach for the sky

Whether they are stretchers, climbers, jumpers, hitchhikers or sunfleck gatherers, all plants are aiming to capture the sun's rays. Here are some of the different strategies they use to reach for the sky.



Staghorn fern

This epiphytic fern has two distinct leaf types. 'Shield' leaves, which are green at first but become brown, are purely structural. They hold the plant in place and contain the roots. As new 'shields' grow on the outside, older ones decompose and provide food for the roots inside. The longer green leaves photosynthesise and produce spores — 'seeds' for the next generation.

Basket fern

This is commonly seen surrounding a tree trunk. The brown bracket, or 'nest' leaves hold the plant together and trap leaf litter for food.

Orchid

Many orchids are epiphytes. Their roots have a spongy sheath of special cells up to 18 layers thick which can absorb water and nutrients rapidly, taking advantage of a shower of rain or cloud or mist. Some orchids are leafless but have green roots which photosynthesise.

Woody liane

Often all we can see of the numerous lianes are woody stems heading up towards the canopy — they seem to have done an Indian rope trick, climbing up without visible support. Actually, as young plants they have wound themselves around saplings which have since died and disappeared. The evidence is the empty woody coils.

Bird's-nest fern

Another epiphyte commonly seen on the branches of forest trees. The leaves are arranged in a funnel to collect falling leaves, which provide it with nutrients, and moisture.

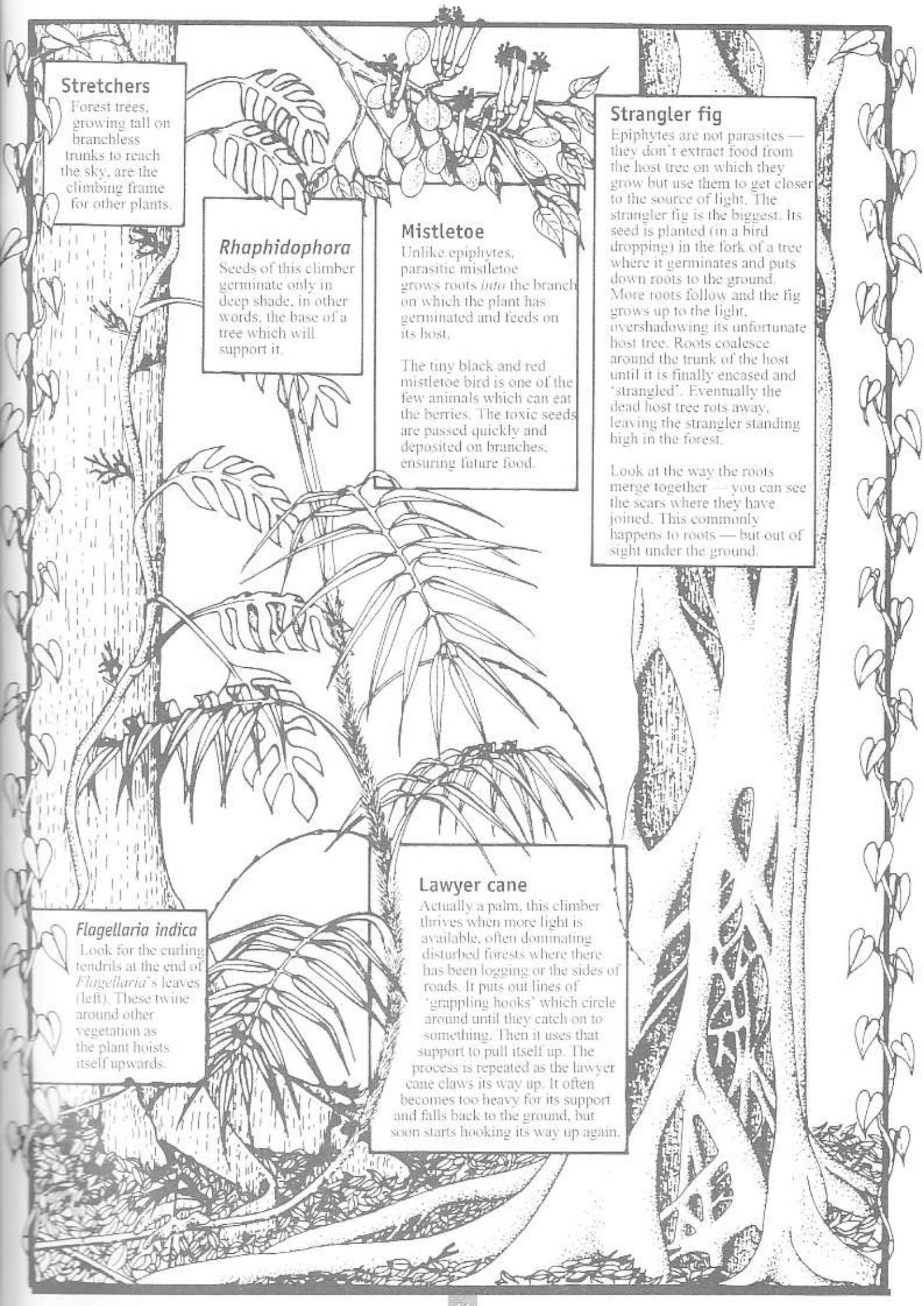
Pothos longipes

To make the best of low light levels, this plant produces what look like double leaves. In fact, each 'leaf' consists of a flattened stem, containing chlorophyll for the process of photosynthesis, and a proper leaf. It climbs up trunks using little claw-shaped rootlets. It is possible that some climbers using rootlets produce a chemical that adheres to tree bark.

Flagellaria indica

Saplings, ferns and other understorey plants

These shade-loving plants feed on sunflecks.



Stretchers

Forest trees, growing tall on branchless trunks to reach the sky, are the climbing frame for other plants.

Rhaphidophora

Seeds of this climber germinate only in deep shade, in other words, the base of a tree which will support it.

Mistletoe

Unlike epiphytes, parasitic mistletoe grows roots *into* the branch on which the plant has germinated and feeds on its host.

The tiny black and red mistletoe bird is one of the few animals which can eat the berries. The toxic seeds are passed quickly and deposited on branches, ensuring future food.

Strangler fig

Epiphytes are not parasites — they don't extract food from the host tree on which they grow but use them to get closer to the source of light. The strangler fig is the biggest. Its seed is planted (in a bird dropping) in the fork of a tree where it germinates and puts down roots to the ground. More roots follow and the fig grows up to the light, overshadowing its unfortunate host tree. Roots coalesce around the trunk of the host until it is finally encased and 'strangled'. Eventually the dead host tree rots away, leaving the strangler standing high in the forest.

Look at the way the roots merge together — you can see the scars where they have joined. This commonly happens to roots — but out of sight under the ground.

Flagellaria indica

Look for the curling tendrils at the end of *Flagellaria*'s leaves (left). These twine around other vegetation as the plant hoists itself upwards.

Lawyer cane

Actually a palm, this climber thrives when more light is available, often dominating disturbed forests where there has been logging or the sides of roads. It puts out lines of 'grappling hooks' which circle around until they catch on to something. Then it uses that support to pull itself up. The process is repeated as the lawyer cane claws its way up. It often becomes too heavy for its support and falls back to the ground, but soon starts hooking its way up again.

A story of Oskars

Although it looks stable, rainforest is continually changing. Old trees fall and others take their place.

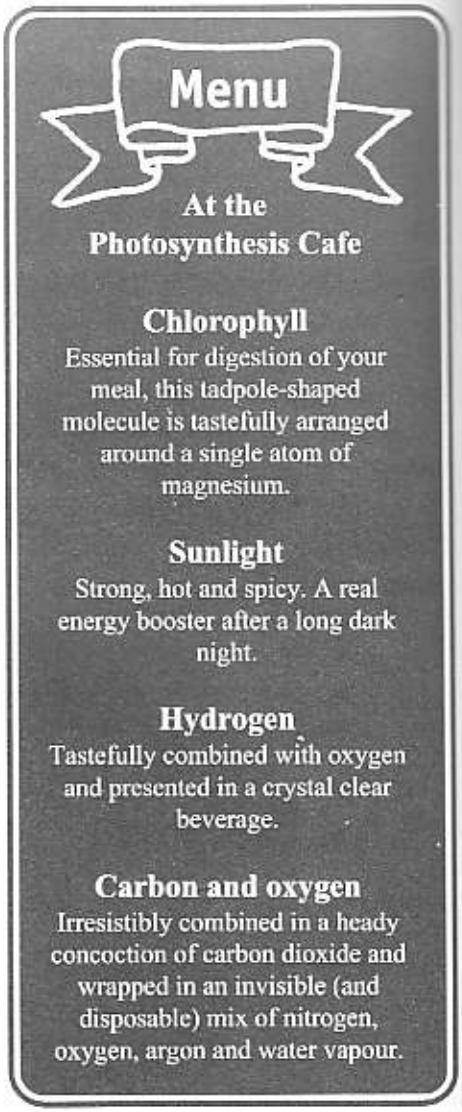
Look around the forest floor. In the gloom, where only one to five percent of available light falls, vegetation is sparse. Apart from ferns, palms and other plants which have adapted to low light levels, there are some spindly saplings with few leaves. Astonishingly, these unimpressive plants may be 20-year-old trees.

Botanists have nicknamed these little saplings 'Oskars'. Oskar, a character in the novel *The Tin Drum* by German author Gunter Grass, was a little boy who didn't grow up. That is what has happened to these saplings. Deprived of sunlight they are unable to reach their potential as magnificent rainforest trees. But there is hope. All they need is a gap in the canopy. Perhaps an old tree or even a branch will fall and give them a chance.

That increase in light is enough. Suddenly energy is available for growth — and the race is on. Generally the largest Oskar wins. Once it reaches the canopy its shade will kill competitors. If, however, there is no gap, Oskars eventually die after a couple of pointless decades of waiting while more germinate, taking their place.

If the gap is large, different types of trees join the race — pioneer species. Unlike the Oskars (otherwise known as climax species) pioneers cannot germinate or grow in low light. Instead their seeds, which remain viable (able to germinate) for much longer than those of climax species, wait for a burst of sunlight. Then they sprout and take off. These pioneer saplings grow much faster in bright light. They are sprinters whereas climax Oskars are long distance runners.

This is not all bad news for the climax species. Pioneers are able to grow in dry hot sunny conditions which Oskars dislike. Some have deep tap roots and can reach nutrient and water stores beyond the reach of shallow-rooted climax species. They prevent soil erosion and create shady damp conditions where more little Oskars can germinate. Usually fast-growing pioneers live for just 20-50 years. Eventually a small gap opens and a patient Oskar on the forest floor has a chance at last. Although slower-growing, these trees live much longer — for hundreds of years. It is these climax species, the long distance runners, which comprise a mature, well-established rainforest.



Recipe

Sugar glucose

The photosynthetic method

First ensure that you have a good supply of chlorophyll (green matter) in your leaves. This is an essential ingredient.

Trap some sunlight and, using your **chlorophyll**, convert it to energy.

Take up some water through your roots. Use some of your energy to split it into **hydrogen** and oxygen.

Breathe in some air. Select the carbon dioxide and split it into **carbon** and **oxygen**. (Don't forget to breathe out excess oxygen. It keeps the animal kingdom alive.)

Finally combine two parts of hydrogen with one each of carbon and oxygen. The result is sugar glucose, your basic building block.

Spice of diversity

As we have seen, growth of the forest varies according to the types of gaps created. It is not only the size of the gap which determines life-and-death issues for hopeful saplings and seeds. The amount of light penetrating to the forest floor can depend on its orientation: an east-west gap receives much more sunlight than a north-south gap. Angles of light change with the seasons and can vary according to slopes. Gaps may appear more frequently in certain places.

The variation is infinite — but the different effects may, to some degree, be responsible for the immense diversity in tropical forests. Research suggests that light conditions in different gaps favour regeneration of different species. Thus variety in gap size — which in natural conditions may be caused by anything from cyclones and landslips to falling branches — is considered, by some scientists, to be the driving force behind biological diversity in the rainforest.

More light notes

Greedy leaves

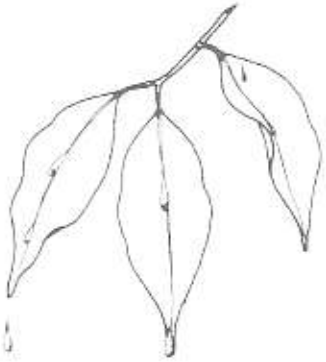
For a young sapling the bigger its leaves, the better are its chances of gathering light. Some forest trees produce young leaves which are very different from the mature leaves.

Darlingia darlingiana produces large, lobed leaves (left) at first. Gradually they become less lobed and the mature leaves (right) are a conventional 'leafy' shape.

Angling for light

When competition for light is as intense as it is in the rainforest, the last thing you want to do is shade your own leaves. Next time you see a sapling, look at the way its leaves are arranged to gain maximum exposure. Many spiral out from the trunk — you can count five or more leaves before you find two growing at the same angle. Others produce their leaves at right angles, each new layer growing out further to avoid shading previous layers.

Drip tips



Many rainforest leaves have a glossy upper surface and pointed leaf tips — known as 'drip tips' — so water runs off quickly. This helps to prevent the growth of algae and lichens which are more likely to take hold on a damp surface. By covering the surface of the leaf, they would cut out light and, therefore, decrease its ability to photosynthesise. Quick rainwater runoff may also prevent the leaf from becoming too cool, which would slow down the activities of the living cells.

Red leaves in the rainforest

New growth on many rainforest plants, notably *Syzygium* species, is often a very attractive red colour, but the reason for this is a long-standing puzzle.

The red or pink is caused by the pigment anthocyanin, (which also gives beetroot its colour). Its actual colour varies from red to brown and purple depending on the pH of the fluid in the leaf cells. Research by Dr Sharon Robinson of the Australian National University suggests that the red colour may act to protect the photosynthetic mechanism inside the new leaves. New red leaves are not yet photosynthetically active — they are still developing the internal organs (chloroplasts) responsible for capturing the sun's energy and converting it to stored energy. Anthocyanin pigment reflects red light like a mirror and absorbs light from the blue end of the spectrum. Anthocyanin can therefore act as a sunscreen, reducing the amount and type of light penetrating the leaf until the chloroplasts mature and can use the light photosynthetically. We see the red colouration because anthocyanin reflects red light away from the leaf and absorbs blues and greens.

Gathering sunflecks

Few plants can survive in the very dim light of the forest floor. Those that do depend on sunflecks — patches of sunlight which dodge the leaves above and reach parts of the floor for as little as a few seconds a day.

Dark green forest leaves are very efficient at capturing sunlight. In addition, these plants seem to respond very quickly when they are lit up. With most plants there is a time lag after exposure to light, before photosynthesis begins. Then, as soon as the light is 'switched off', the rate of photosynthesis begins to decline. However, research indicates that forest floor plants switch on quicker — as soon as the sunfleck hits them — and continue to photosynthesise longer after the light has gone.

Facts and stats

on light and leaves

During a day, a hectare of forest can cycle 500 000 litres of carbon dioxide. With all plants on the earth doing this our atmosphere is completely recycled about every 250 years.

Chlorophyll, the green matter in leaves, has existed for at least two billion years. Its decomposition products have been found in rocks containing algae of that age.

Almost all the oxygen in the earth's atmosphere (20 percent) has been derived from photosynthesis over the past two billion years.

The long red and short blue wavelengths of visible light are absorbed more easily by chlorophyll than medium wavelengths. Most of these are reflected and enter our eye producing the effect we recognise as green.

Although 75-80 percent of the sunlight falling on a leaf is absorbed, only about 10 percent is actually captured by the chlorophyll and turned into energy.

Almost all twiners twist themselves in an anti-clockwise direction — whether in the northern or southern hemispheres. Scientists are still trying to understand why.

Epiphytic ferns can become very heavy and break branches off trees. Some trees have defence mechanisms against epiphytes. Very smooth bark discourages them from gaining a roothold. Others have flaky bark which pulls away from the tree with the epiphyte's weight. It is thought that some trees may produce a toxin to inhibit epiphyte growth.

Bookshelf

There are no books, as such, on light in the rainforest but a number of chapters and articles tackle the subject.

New Scientist 14 March 1992
Logging rainforests the natural way?
Nick Brown and Malcolm Press

Although dealing with forests in Borneo, this article has much relevant information on the effect of sunlight in various gaps on forest regeneration, plus an interesting section on sunflecks.

Australian Tropical Rainforests
L.J. Webb and J. Kikkawa
CSIRO (1990)
Chapter: *Disturbance: The Forest Transformer*
M.S. Hopkins

This chapter looks at regrowth after both natural disturbances, including cyclones, and 'man-sized gaps'.

Tropical Forest and its Environment
K.A. Longman and J. Jenik
Longman Scientific and Technical (1974/1987)

While only a few pages deal with light and shade, this book has a wealth of general information on the forest and its dynamics. Sections include the forest and environment interacting, environmental factors, the forest community, tree growth physiology, dynamic forest ecosystems and management of tropical forest land.

Tropical Rainforest Research in Australia
N. Goudberg et al, Ed.
Institute for Tropical Rainforest Studies (1991)
Chapter: *Aspects of the Micrometeorology of Rainforests in the Wet Tropics of Northeast Queensland*
S.M. Turton

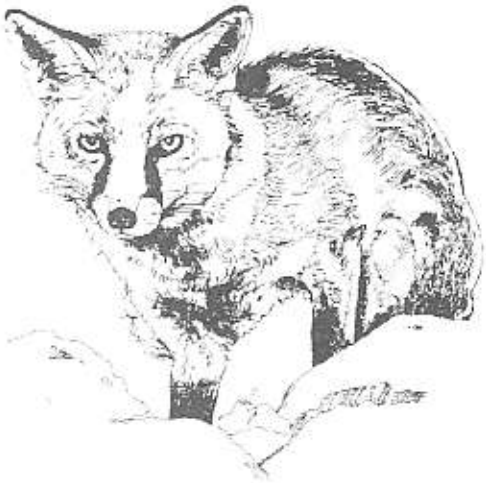
The Ecology of Australia's Wet Tropics
R. Kitching Ed.
Ecological Society of Australia (1988)
Chapter: *Solar Radiation Regimes in a North Queensland Rainforest*
S.M. Turton

Tourist talk

ENGLISH	GERMAN	JAPANESE	
sun	Sonne	taiyo	太陽
light	Licht	hikari	光り
leaves	Blätter	ha	葉
photosynthesis	Photosynthese	kougousei	光合成
gap	Lücke	aida	間
canopy	Baum-kronen	zaikan	材冠
shade	Schatten	ka-ge	陰
epiphyte	Epiphyte	chakusei shokubutsu	着生植物
germinate	keimen	hatsuga suru	発芽する

Truffles, treeroots, bettongs and foxes

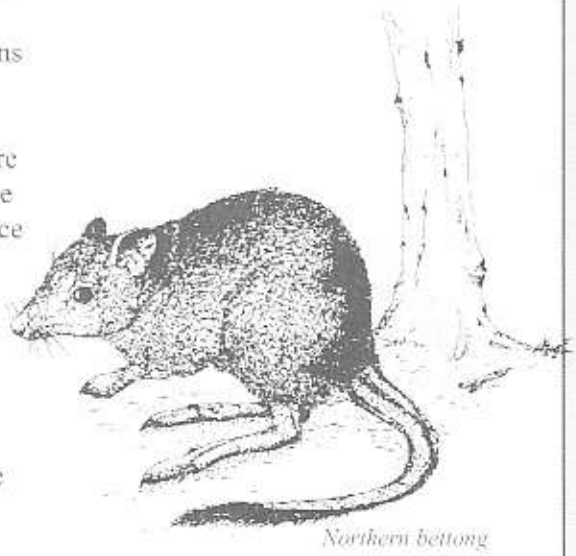
Some fungi are parasitic on living wood and give no benefit to their hosts. However, there are a number of specialised fungi, called mycorrhizae, which form associations with plants which benefit them both. They wrap themselves around the roots, lightly penetrating them and feeding on sugars produced by the plants from photosynthesis. In return the fungi feed water and elements such as nitrogen and phosphorous into the roots. These associations are common and are important to plants in Australia where soils are relatively poor in nutrients. A plant may die when deprived of the benefits of this symbiotic relationship.



Some of these fungi send their fruiting bodies — familiar to us as toadstools or mushrooms — above the ground where wind and other forces disperse their spores. However, some mycorrhizae fruit below the ground. In rainforest the fruiting bodies tend to be small and close to the surface and can be dispersed by cassowaries or any foraging animals which pick up soil with their food. However, in drier areas mycorrhizae produce truffle-like fruiting bodies further below the ground.

For dispersal of their spores these fungi rely on the help of mammals — particularly members of the potoroid family, such as the northern bettong (*Bettongia tropica*). This little marsupial makes shallow excavations in the ground, feeding on bulbs, tubers, roots and large numbers of truffles. The spores of the truffles are not spoiled in the bettong's digestive tract; in fact the journey may enhance their germination prospects. The bettong is the main disperser for these mycorrhizae and is therefore very important for maintaining healthy forests.

Enter the fox. Northern bettongs are not common and exist in small pockets but the recent sightings of foxes near Kuranda and not very far from a major bettong population concentration has alarmed researchers. Not only is another of our marsupials at risk from an introduced species (which is thought to have moved north, following an increase in rabbit populations on the Atherton Tableland) but its loss could deprive the mycorrhizae of their main disperser and the forests, in turn, of some of the fungi which help to feed them. It would be one more break in the complex webs of interdependence which characterise our ecosystem.



Northern bettong

Intricate webs

Plants and animals use each other in a variety of ways. Only plants can produce food from soil, sun and water so many animals use them as a food source as well as for shelter. Animals, on the other hand, are able to move around — so plants utilise them to carry their pollen and their seeds. And, of course, plants use other plants — and animals make use of each other as well.

When both participants in an association are entirely dependent on each other the relationship is a symbiotic one. Often, however, both parties benefit from each other without being dependent in which case it is referred to as mutualism. Then, as with parasitism, one party may benefit to the disadvantage of the other. Alternatively, one party may not be affected at all. In addition, many relationships are not exclusive but involve several parties in a complex web of interactions which become increasingly fascinating as we discover more links.

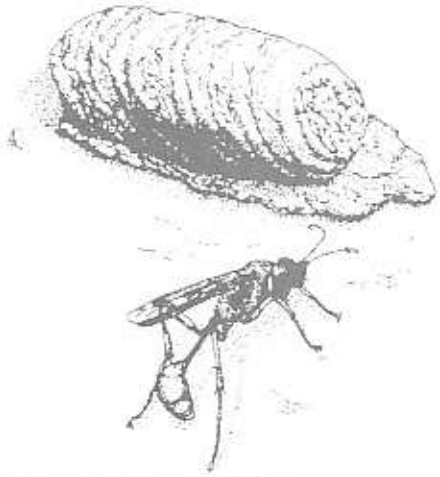
Mixed relations

Most plants and animals participate in some sort of interaction with other organisms. Here we look at some of the more curious relationships which contribute to the webs of life in the Wet Tropics.

Spiders are well-known for their ability to prey on insects (and even birds). Some ambush from under trapdoors or burrows. Others camouflage themselves as parts of flowers and leap on unsuspecting prey.

However, spiders are characterised by their webs. Net-throwing spiders spin tiny, elastic webs which they fling over prey which comes close enough. On the other end of the scale golden orb weavers (*Nephila*) construct huge webs between trees and even telegraph poles while 20 to 30 corroboree or community spiders (*Cyrtophora moluccensis*) (left) build their webs together so they form huge sheets.

Some spiders obtain their food from others' webs. Tiny **dew drop spiders** (*Argyrodes*) (left, below) live on the edges of the giant webs and feed on insects which are too small for their hosts. The larger spiders benefit by having their webs cleaned up for them.



Spiders don't have it all their own way; some become kindergarten food for the larvae of **mud-dauber wasps**. These wasps build clay cells from damp mud. Before closing each pot the female wasp hunts down a spider, paralyses it and carries or drags it to the nest. After laying an egg on the spider the mother seals the cell and leaves. The larva hatches to find a ready food supply in the form of a fresh, live, but helpless spider.

Some species of wasps, instead of building mud pots, attack funnel-web or trapdoor spiders in their homes, leaving an egg with each paralysed host in a ready-made nest. Another species simply lays an egg on a spider which continues as normal until the developing larva gradually eats it alive!

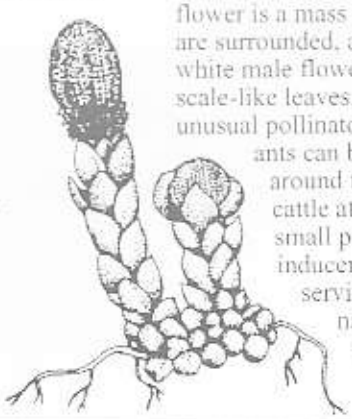
Fruit-piercing moths are a common sight on the rainforest edge and in orchards where they pierce fruit skins with a 'drill bit' on the end of the proboscis and pulp the interior. Their larvae feed on the vines of the Menispermaceae family. CSIRO scientists were puzzled at the tendency of native moths to lay on certain native vines (*Stephania hancroftii*) in this family which are actually toxic to the caterpillars.

Their research came to the notice of a Chinese immunobiologist who was looking at the medicinal qualities of a similar vine (*S. tetrandra*) used in traditional Chinese medicine for reducing inflammation. It was also discovered that Australian Aborigines traditionally wrap the leaves of another related vine (*Tinospora smilacina* — illustrated here) around swollen joints to reduce inflammation.

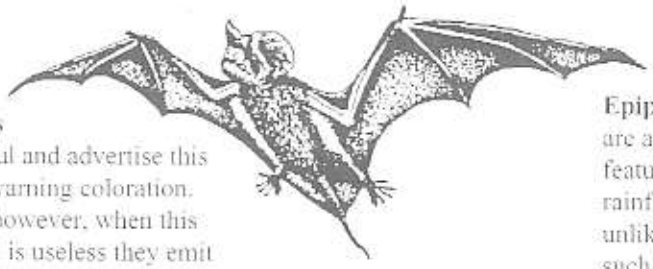
By looking at how caterpillars concentrate the alkaloid toxins in their bodies the scientists were able to extract alkaloids with immunosuppressant qualities. It is hoped these, or similar compounds, may be useful in the fight against abnormalities of the immune system such as silicosis, asbestosis, arthritis, cancer and AIDS.

Geoff Thompson, Queensland Museum

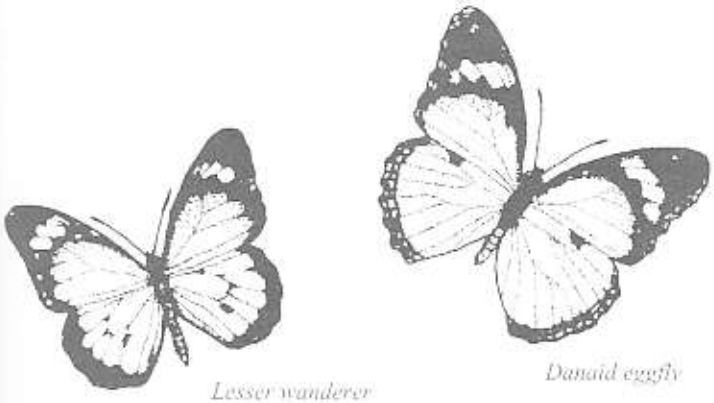
Because it produces no chlorophyll the plant, ***Balanophora fungosa***, is unable to produce its own food from sunlight so it lives as a parasite on certain roots. In winter its strange flowers are a common sight on the rainforest floor as they push, mushroom-like, through the leaf litter. Despite its characteristics and appearance and its common name — fungus root — *Balanophora* is not actually a fungus.



The creamy-brown knob at the tip of the flower is a mass of female flowers. These are surrounded, at the base, by a ring of white male flowers. Below these are a few scale-like leaves. Although they are unusual pollinators, early in the morning ants can be seen in large numbers around the female head — 'like cattle at a pond' — feeding on small pools of liquid, their inducement for pollination services. It is thought that native rats, which eat the male flowers, may also carry pollen.



Some **moths** are distasteful and advertise this fact with a warning coloration. After dark, however, when this visual signal is useless they emit ultrasonic clicks which can be picked up by insectivorous bats. This may simply warn the bats of the moths' unsuitability as dinner or may even serve to jam the bats' sonar system.



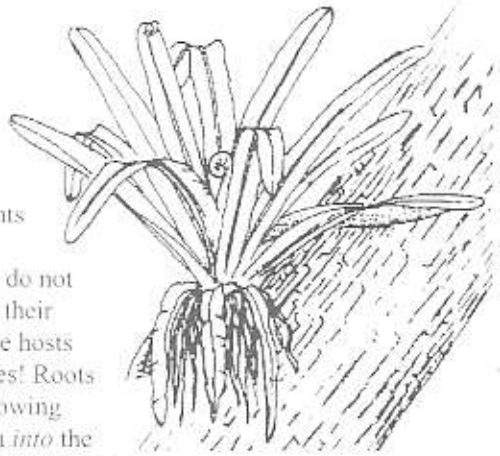
Lesser wanderer *Danaid eggfly*

Red for danger is a common signal in the animal world. Bold combinations of red, yellow, orange, black and white frequently indicate that an animal is distasteful or poisonous. This is the case with the orange, black and white **lesser wanderer butterfly** (*Danaus chrysippus*). The female of the **danaid eggfly** (*Hypolimnas misippus*) looks almost identical — but it is an imposter. Unlike the wanderer it would make a tasty meal for a bird but undoubtedly benefits from its similar appearance when the predator is reminded of a previous unpleasant experience.

Mimicry such as this, when a harmless species mimics a harmful one, is common in the insect world. Beetles, flies and other insects mimic stinging wasps, even flicking their wings in the same way. Mimicry can also disguise a predator.

Termite mounds, on the ground and in trees, make good nesting spots and are used for this purpose by many species of kingfishers and some parrots. **Kingfishers** begin their excavations by flying at the mounds, missile style, with their beaks held out straight ahead (and sometimes die from the impact). They then peck out a nesting chamber which is later sealed off on the inside by the termites. (The termites may eventually benefit from this invasion of their territory by feeding on nutrients left behind by nesting birds.)

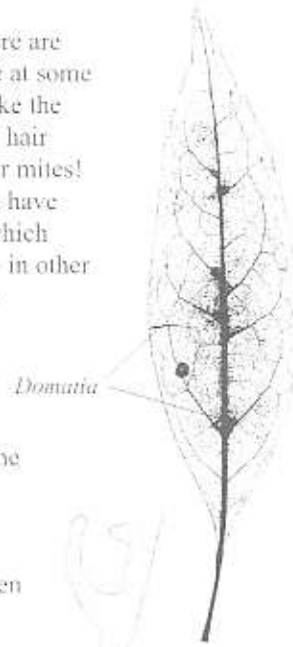
Buff-breasted paradise kingfishers nest in termite mounds on the ground.



Epiphytic ferns are a common feature of rainforests. While, unlike parasitic plants such as mistletoes, epiphytes perch but do not steal nutrients from their hosts, sometimes the hosts feed on the epiphytes! Roots have been found growing *from* the tree branch *into* the epiphytes. This is similar to the marcotting process, used to propagate trees by covering a treated branch with moss and plastic until a root system develops.

On the undersides of many leaves there are little growths called **domatia**. Visible at some junctions of major veins, these can take the form of tiny pits, pouches, pockets or hair tufts — and provide perfect homes for mites! Studies of the mites found in domatia have shown that they are usually species which feed on fungi and on leaf parasites — in other words, mites which benefit the plant.

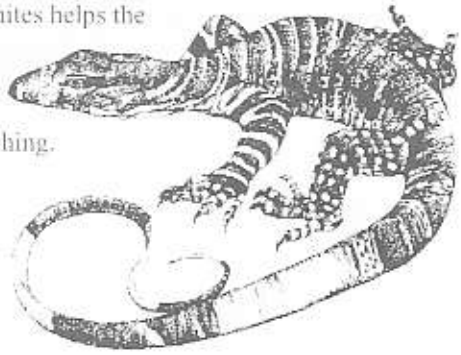
It seems that the plant provides the domatia as havens where the mites can shelter and reproduce, while the mites pay rent by keeping the leaf surface clear of destructive invaders. This beneficial mite-plant association appears to be ancient, 40-million-year-old fossils having been found in New South Wales and in Victoria. Domatia are particularly common on leaves of quandongs (*Elaeocarpus* species).



Cross-section of magnified pouch domatia

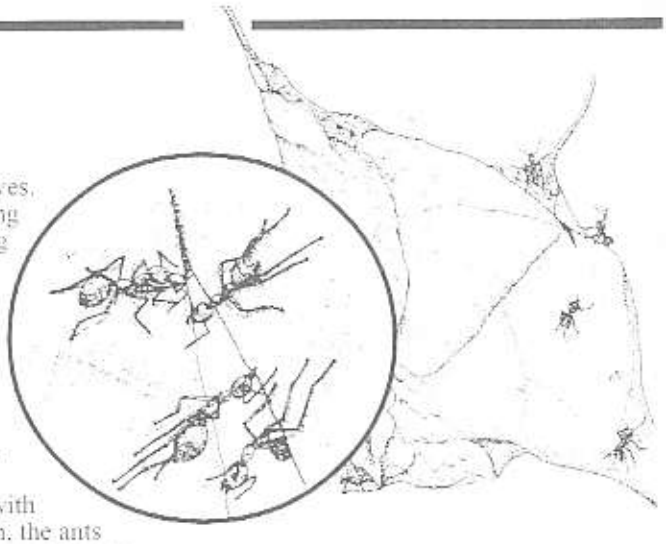
Elaeocarpus leaf courtesy CSIRO

Lace monitors nest in termite mounds in trees. In this case the termites fill the hole made by the mother, cementing in the eggs and repairing the mound so that there is almost no trace of the lizard's nest. Inside, the constant temperature maintained by the termites helps the eggs to incubate. It is thought that the mother returns to the nest at the time of hatching.



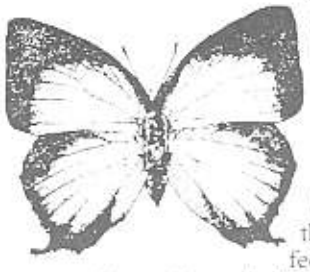
Ants in the plants

Ants are great mixers



Green tree ants (*Oecophylla smaragdina*) build their nests from leaves. Working as a team they bridge the gap between leaves — sometimes forming chains to do so. They draw the edges of the leaves together and then, using their own larvae as 'glue-sticks', join the leaves with silk produced by the grubs. The ants benefit by having a home but the tree also benefits because its branches and leaves are swarming with aggressive defenders ready to attack most leaf-eaters which approach their home.

The ants, however, are willing to share their home with another creature — the caterpillars of some butterflies in the Lycaenidae family (which includes the 'blues' such as the common oakblue, below). When laying eggs the female butterflies often search not only for the correct food plant but also for the presence of ants (different species associate with different species of ants). When the eggs of some butterfly species hatch, the ants carry the little larvae into their nest. As they grow they are attended by the ants which clean them and probably protect them from predators and parasites. (The skin of caterpillars attended by ants is thicker than the skin of other caterpillars.) The ants also guide the caterpillars when they emerge from the nest to feed on leaves at night.



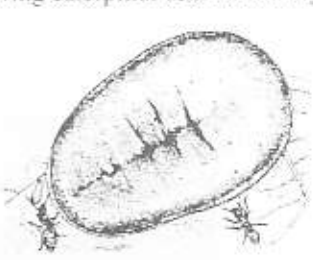
The ants' reward is a sweet substance, referred to as honeydew, a mixture of sugars and amino acids produced by the caterpillars. It is thought that this substance, apart from feeding the ants, may also reduce their aggression towards the caterpillars. It has also been observed that some caterpillars, when disturbed, perform jerky movements which, although driving away some attackers, often provokes aggression in ants. This behaviour, however, is not found in lycaenid larvae and may be a further adaptation to their association with ants.

Other insects such as aphids, scale insects and leaf hoppers also produce honeydew and are also herded by ants.

These caterpillars may also actively attract ants by calling! Some have been recorded producing a vibratory sound which carries for up to five centimetres along stems and leaves. This may mimic similar calls used by the ants to communicate with each other. Certainly it seems to attract the ants to the caterpillar, keeping them with it to provide a bodyguard instead of returning to the nest after feeding on its honeydew. When the vibratory papillae used to make the call were experimentally removed from some caterpillars, they did not receive such good protection against enemies.

While some of these caterpillars can survive without the ants, others cannot. When separated, experimentally, some species refused to eat while others became mouldy and died.

In spite of their bodyguards, however, the caterpillars are not completely safe from parasitic wasps and flies. An adult fly may lay her eggs on the leaf of the food plant where they are eaten up by the caterpillar. The eggs then hatch and develop inside the growing caterpillar and eventually emerge from it or from the pupa.



Not all caterpillars have such a mutually beneficial relationship with ants. Some, instead of providing food for the ants, feed on their unwilling hosts' larvae. Notable among these are the larvae of the ant butterfly (*Liphyra brassolis*) which find their way into green tree ant nests from eggs laid nearby. They are protected by a very tough, flat, shield-like skin and, when hungry, drag ant larvae underneath it for a meal (above right). Unlike other butterflies these caterpillars produce their soft pupae inside the protection of their final larval skin. When they emerge as butterflies they are covered with loose scales which stick to the antennae and mouths of attacking green ants, allowing them to make their escape from the nest.

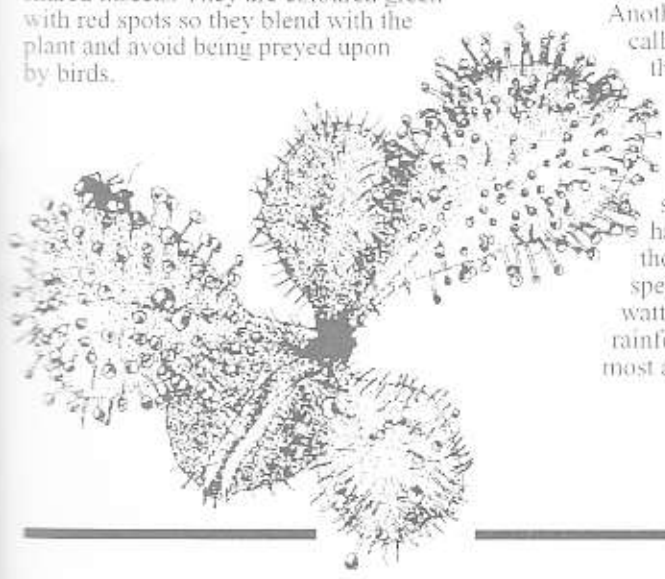
Various bird species are able to make good use of the defensive fluid, formic acid, which ants produce, to kill ectoparasites such as lice and ticks as well as fungi in their feathers. They do so by picking up an ant in their beak and running it over their plumage, particularly the inside of their wing feathers. Another strategy is to squat over an ants' nest with wings spread and passively 'bathe' in ants by letting them run all over it. 'Anting' has been reported in various species including satin bowerbirds, currawongs and many honeyeaters, particularly eastern spinebills.

The aggressive green tree ants themselves are not immune from attack. A spider (*Amyciaea albomaculata*) mimics the body shape and colour of the green ants. From behind, its abdomen resembles an ant's head with two black spots for eyes. At the other end it raises its long front legs in imitation of an ant's antennae so it looks like the front of an ant at both ends! It is thought that when the spider hangs from its silken thread it resembles an ant in trouble but when the unsuspecting companions come to help it they are ambushed instead!

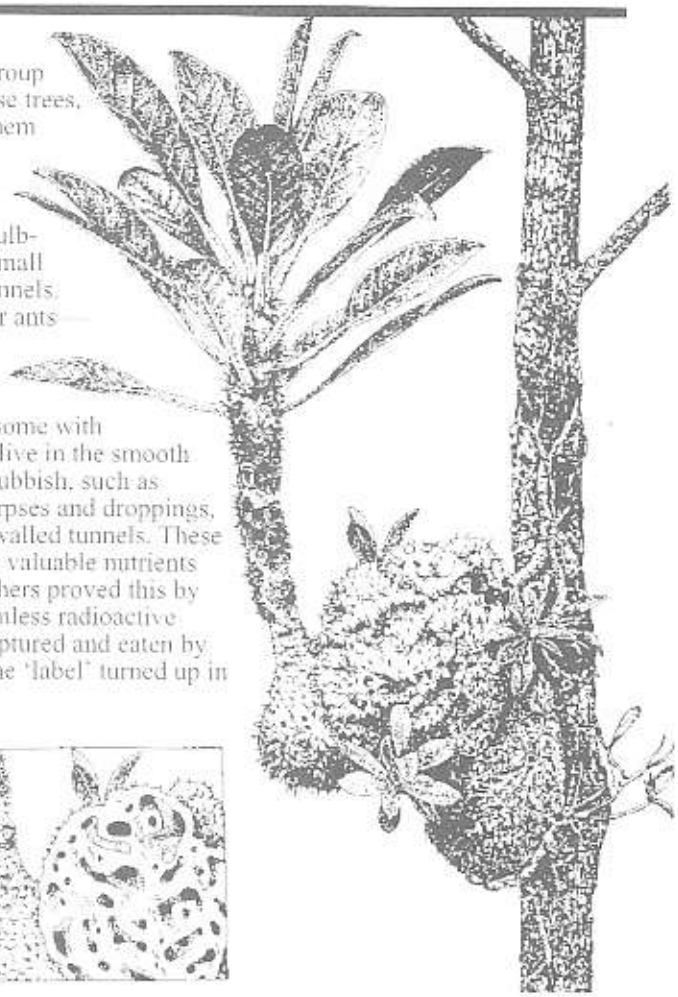
Spiders are not the only enemies in disguise. An appropriately named assassin bug also closely resembles a green tree ant and joins their trails, pouncing on its unsuspecting prey. One of its relatives in the Reduvid family (subfamily Holoptilinae) has another strategy for capturing ants. From a gland on its abdomen it secretes a substance which they find irresistible. It is, however, a narcotic which makes the ants, once under the influence, very easy prey!

Ants do not have it all their own way. They are a favourite prey of insectivorous plants — those plants which live in areas of poor soil nutrients and rely on insects as an additional source of food. The most common of these insectivorous plants in our area are the various drosera, or sundews. When ants and other insects wander on to a leaf they are trapped by the long hairs and sticky droplets which cover the surface. Over a few days the leaf slowly closes, the sticky droplets gradually digesting the trapped insects.

But living on the sundew are predators which beat the plant at its own game! Tiny bugs, of the genus *Setocoris*, are adapted to avoid the sticky droplets and can move about extracting juices from snared insects. They are coloured green with red spots so they blend with the plant and avoid being preyed upon by birds.



One particularly interesting group of epiphytic plants not only use trees, such as paperbarks, to hoist them closer to the light but also depend on certain ants (of the genus *Iridomyrmex*) for food. These ant-plants have short bulb-like stems with a number of small natural holes which lead to tunnels. This makes a perfect home for ants and they invariably move in.



There are two types of tunnels — some smooth and some with rough walls. The ants tend to live in the smooth ones but as they accumulate rubbish, such as remains of insect prey, ant corpses and droppings, they store them in the rough-walled tunnels. These act like an intestine absorbing valuable nutrients from the ants' waste. Researchers proved this by putting tiny amounts of a harmless radioactive 'label' on flies which were captured and eaten by the ants. Several hours later the 'label' turned up in the plants leaves!

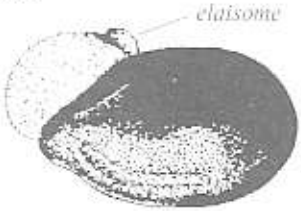
The ants are not the only residents of the ant-plant. Another member of the Lycaenidae butterfly family, the Apollo jewel, spends its larval stage inside the plant too, feeding honeydew to the ants which tend it and eating the ant-plant tissue and leaves. Thus there is a mutually beneficial relationship between the ants and the plant as well as between the ants and the butterfly, the butterfly depending on the plant for food while all of them ultimately rely on the tree which hosts the ant-plant.

Unfortunately ant-plants are being taken over by colonies of ants which have been introduced to Australia. They do not appear to take care of the butterfly larvae and the seeds of ant-plants in which they live do not set well.

To prevent disease breaking out in their colonies, many ants smear themselves with a substance which is a powerful antibiotic. A pollen grain which comes into contact with it dies within minutes so ants are not good pollinators (although there are exceptions). Possibly because of this, the small white flowers of the ant-plant are designed to prevent ants from reaching them.

Ants are major predators of many seeds, especially eucalypts. Plants in dry areas therefore benefit from fire. Apart from opening the seed cases, fire produces an ash bed which discourages ant mobility, and allows the seeds to escape predation.

Another strategy for plants is to attach a food parcel, a nutrient-rich structure called an elaiosome, which encourages the ants to carry the seeds back to their nests. The ants then eat the elaiosome and discard the seed. In return for providing food, the seeds are carried away from the competition of their parent tree, they are planted in a nutrient-rich environment (the ants' waste heap) where they may be hidden from bush fires, and are protected by the aggressive ants from other seed-predators. Some may be scarred in the process, but this may actually enhance germination. Studies have found that seeds in ants' nests produced more successful plants than those in other places. It is estimated that about 1500 Australian plant species have seeds with elaiosomes. These include wattles and acacias growing in disturbed rainforest areas. No eucalypts have them but most acacias do.

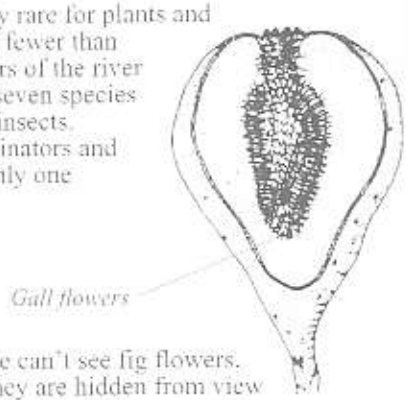


Go-betweens

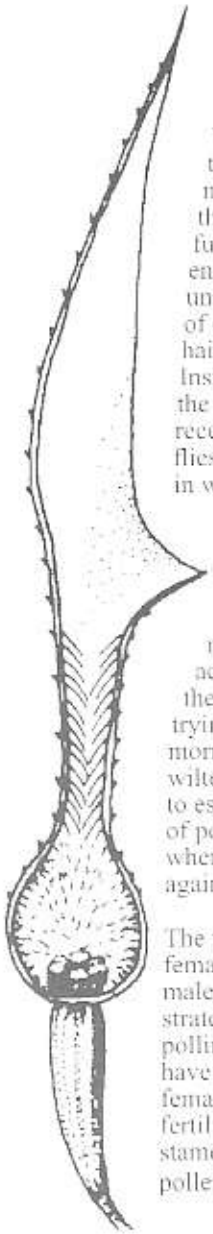
Pollination is one of the tightest mutualisms between plants and animals. In Australian rainforests wasps, bees, ants, beetles, flies, butterflies, moths, thrips, cockroaches and other insects as well as birds, bats, possums, rats and marsupial mice are all potential pollinators.

Usually food is offered by the plant as a reward for pollination services but sometimes other appetites are appealed to. Orchids of the genus *Cryptostylis* have discovered how to make use of the sex drive of an ichneumonid wasp, *Lissopimpla excelsa*. The flower looks and smells like a female wasp to the extent that the male wasp tries to mate with it. In the process he becomes covered with pollen and then, not having learned from his mistake (or perhaps even noticed it) he goes off to repeat the experience with another flower! This is not a mutually beneficial relationship — the flower wins this one!

Despite this example and others below, it is fairly rare for plants and pollinators to have a one-to-one relationship. No fewer than 44 species have been recorded visiting the flowers of the river cherry (*Syzygium tierneyanum*) including a bat, seven species of birds, nine butterflies, 16 moths and 11 other insects. Probably most plants depend on a variety of pollinators and vice versa. To rely on only one food source or only one pollinator is a risky business.



Gall flowers



The flower of the pipe vines, *Aristolochia* species, holds its pollinators captive. Tiny flies are attracted to the flower by its mousy smell. Following the odour they move further into the bulbous end of the flower but are unable to get out because of downward-pointing hairs which trap them. Inside, the female parts of the flower are active and receive pollen from any flies which have carried it in with them.

During the night the female parts of the flower become unreceptive and the male stamens become active, shedding pollen on the flies as they fly around trying to escape. In the morning the hairs have wilted and the flies are able to escape, bearing their load of pollen to the next flower where the process begins again.

The timing involved, with female parts ripening before male parts, is a common strategy to avoid self-pollination. If the pollinators have been doing their job, the female parts have been cross-fertilised by the time the stamens begin to produce pollen.

We can't see fig flowers. They are hidden from view inside the hollow rounded fruit and only tiny wasps of a particular kind (Agaonidae) ever visit them. Three types of flower line the inside of the fig male, female and gall flowers. The female wasp flies in a small hole at the top of the fig and, before dying, lays her eggs in one of the special gall flowers at the bottom of the fig.

When the male wasps hatch, they seek out the females, mate with them (before they have emerged from the gall flowers) and die. The females then swarm around the inside of the fig, cross-pollinating the male and female flowers, before escaping through a hole chewed in the side and flying off to other figs to begin the process again.

Tropical figs tend to fruit all year so the wasps' reproductive cycle is not broken (and there is a permanent supply of food for birds, and so on.)

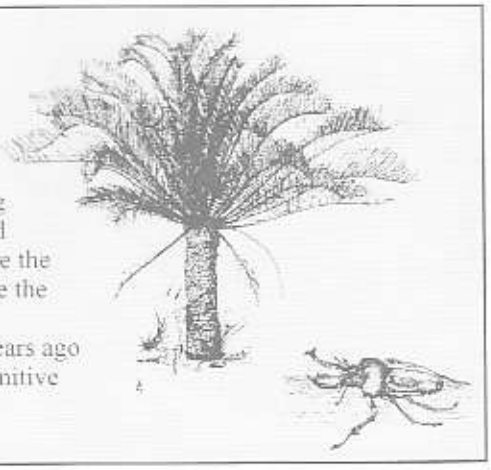
The details of pollination differ slightly from species to species, each fig being pollinated by its own particular wasp species, but in all cases neither wasp nor fig could reproduce without each other. It is a strictly symbiotic relationship.

The rainforest shrub bolwarra (*Euponatia laurina*) is one of the primitive flowering plants of the Wet Tropics. Strangely, what appear to be creamy, heavily perfumed petals are, in fact, sterile stamens (the male pollen-producing parts of the flower) which are fused together. They resemble petals and have taken on the function of petals, attracting tiny weevils of two species which are the flower's only pollinators.

While climbing around and feeding on the 'petals' the weevils carry pollen from adjacent fertile stamens to the female stigmas. The weevils then mate and lay eggs on the 'petals'. After a day the spent flower falls to the ground where the eggs hatch, the larval weevils feeding on the stamens until they pupate and emerge as adults in 14-16 days.

What the weevils feed on until the bolwarra blossoms a year later is unknown, but wherever bolwarra flowers open, even when taken to forest areas where the plant does not exist, the weevils appear within an hour. No other insects are found on this flower so if the weevils were to become extinct the bolwarra would probably follow.

The first pollinators



Early plants relied on the wind to carry pollen but about one hundred million years ago some plants began to use flying insects as pollen couriers. Beetles had fed on the pollen of the early cycads and were the first to be used by flowering plants before the evolution of nectar involved bees, flies, butterflies and birds. By 40-50 million years ago flowering plants had overtaken more primitive forms of vegetation.

Birds, not bees

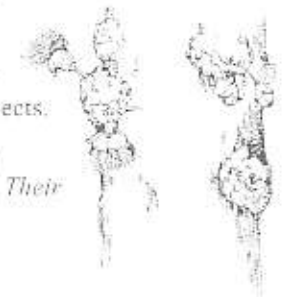
Birds, like bats, are important pollinators in the tropics. Worldwide there are said to be 2000 bird species of 50 families which visit flowers regularly; two-thirds relying largely on them for food.

This relationship is of particular significance in Australia where more than 70 different honeyeater and lorikeet species are nectar-feeders and over 1000 plant species are bird-pollinated. By comparison, there are no bird-pollinated flowers in Europe.

Bird-pollination involves our major plant families (eucalypts, grevilleas, banksias and melaleucas) and our two major bird families (honeyeaters and parrots). Possibly a lack of large social bees in the distant past led to this close dependence. In any case, it has played a central role in the evolution of Australia's distinct flora; Australia (and neighbouring islands) is the only place where the dominant trees are bird-pollinated.

Our bird pollinators are also particularly large — Africa's largest sugarbird is one-third the weight of our rainbow lorikeet.

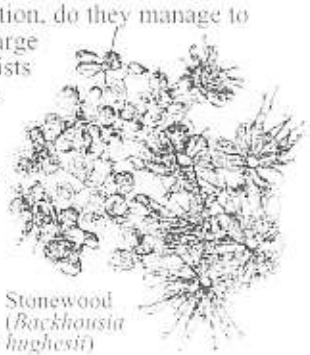
Since birds cannot smell, these flowers are frequently brightly coloured and produce copious quantities of thin nectar. They are also sturdy enough to hold a bird's weight and are often produced on main branches and trunks. Some pollination may also take place incidentally as birds visit flowers to feed on insects.



Scarlet satinash (Syzygium erythrocalyx) *and bumpy satinash* (S. cormiflorum) *are trunk-flowering trees of the Wet Tropics. Their flowers are pollinated by blossom bats, birds and insects.*

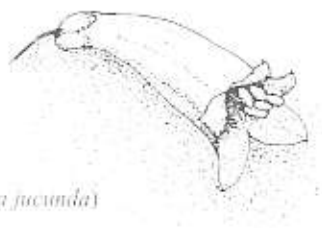
Persuasive plants

Tropical forests are famous for the diversity of species but how, when trees of the same species generally occur too far apart for reliable wind pollination, do they manage to persuade animals to carry the pollen from one to another? Large animals, such as bats and birds, are very important but scientists have discovered strategies which may also encourage insects to make the journeys.



Stonewood (*Backhousia hughesii*)

- Some trees produce masses of blossom, attracting a large number of pollinators. Aggression between competing visitors may provoke some to move to the next tree. Alternatively, most of the pollination may take place towards the end of the flowering period when the insects run out of food and are forced to move on. Relatively few seeds are produced by these types of trees.
- Small, inconspicuous flowers produced over a longer period of time may attract certain insects (moths and bees) which fly along the same route each day often covering quite large distances. Seed production in these species is high.
- Some species have male and female trees. The male trees flower first so when the female trees are ready, 1-4 days later, there are plenty of insects covered with pollen.
- Female flowers, without nectar, can mimic male flowers, encouraging the foragers to move between them.
- Many trees synchronise their flowering but some species may produce flowers or nectar at slightly different times to encourage movement of insects.



Jungle vine (*Neosepicaea jucunda*)

Age brings wisdom

Why do some flowers change colour as they get older? It is thought that by retaining old flowers the plant increases its long-range attractiveness to pollinators. At closer range, young butterflies have been observed to visit all flowers while older butterflies visit only the younger, sexually viable flowers. Presumably these insects learn from experience.

Flowers of the box fruit (Barringtonia asiatica) *blooms only in the late afternoon or evening. Its flowers are probably pollinated by large hawk moths and may attract lightly-built blossom bats. By the end of the night the petals and the mass of stamens have fallen to the ground.*

The scarlet flowers of the coral tree (Erythrina variegata) *welcome pollinators with generous amounts of nectar.*

Flower strategies

To avoid pollen being wasted on the wrong species of plant as the pollinators move around, many flowers have developed characteristics which appeal to certain types of pollinators. Strategies include:

- producing yellow, blue and purple flowers which can be seen by bees as well as special markings which indicate the location of the nectar. These are visible to us only under ultra-violet light.
- producing abundant pollen instead of nectar to attract bees and certain beetles.
- keeping the nectar at the end of long tubes where it can be reached only by birds or insects with long tongues (smaller insects being excluded by hairs). Others can be opened only by heavier animals.
- producing a strong scent at night to attract moths and bats. These flowers are usually pale-coloured.
- imitating the smell of rotting meat, to attract fly pollinators.
- flower construction designed so that the visiting insect first encounters the female part which receives any pollen being carried. The insect then moves further into the flower where it encounters the stamens and collects another load of pollen while attempting to reach the nectar.

Witches tongues (*Clerodendrum tracyanum*)

Illustrations courtesy Queensland Museum

A tale of toxic birdwings

Plants cannot flee when attacked by predators but they have one strong defensive tactic up their sleeves — poison.

The rainforest is full of toxic plants — but not all animals are equally affected. Birds can be seen feasting on fruit which poison humans. Green possums munch happily on stinging tree leaves which other possums (and wise humans) avoid. It seems that in the course of evolution different animal species have developed particular methods for dealing with certain toxins — abilities which determine the diet of each species.

The female birdwing butterfly (of both Australian species) lays her eggs on the leaves of *Aristolochia* vines. She manages to locate the correct plants by 'tasting' various leaves with chemical receptors in her forelegs, searching for chemical cues. She also uses sense organs at the end of her abdomen to find tender young leaves suitable for caterpillar food.

Aristolochia vines are poisonous. For many newly-hatched caterpillars the toxins would be deadly but the birdwing not only copes with them but also uses them for its own protection. The caterpillars store the toxins in their bodies and in prominent fleshy orange-red spines on their backs. Should a bird ignore the obvious warning these represent, it is unlikely to repeat its mistake.

But that is not the end of the toxic tale. *Aristolochia* vines have intriguing flowers which have earned them their common name, Dutchman's pipe. A South American species, *Aristolochia elegans*, produces particularly large and attractive flowers and has been introduced to Australia as an ornamental plant. Unfortunately the female birdwing butterfly receives the correct chemical cues and is fooled into laying her eggs on it — but her caterpillars are eventually poisoned by the toxins of this particular vine. Sadly this plant is spreading from gardens into the natural environment and, along with habitat destruction, is endangering the future of the beautiful birdwings.

Last meals

When birdwing butterfly caterpillars are almost ready to pupate they ringbark the vines on which they are feeding. This causes the leaves to droop through loss of water but does not stop nutrient flow. The large (and very hungry) caterpillar therefore gets a higher dose of nutritious solids and less water — a more nutritious last meal before pupation.

Helping the birdwings

If you want to help the birdwings, try planting *Aristolochia tagala* or *Pararistolochia deltantha*, between Cooktown and Mackay (for the Cairns birdwing) or *A. praevenosa* in the Brisbane area (for the local Richmond birdwing). Your reward may be the marvellous sight of their mating flights.

Two caterpillar-killing vines to avoid, or pull out of your garden, are *Aristolochia elegans* and *A. ringens*. The latter vine has appeared in the Wet Tropics more recently. You can tell these South American species from the native ones by their heart-shaped leaves which are as wide, or wider, than they are long. Their flowers are much bigger and more rounded than the native ones. Those of *A. elegans* reach 5cm in diameter while those of *A. ringens* grow to 14cm. Their seed pods are long and thin with straight parallel sides.

In contrast to these exotic vines, the native *A. tagala* (right) has more elongated leaves, much smaller flowers and rounded fruits.

Spreading the seeds

Next to pollination, one of the most intriguing and important interactions to have evolved between plants and animals is seed dispersal.

Mechanical means of seed dispersal (such as winged seeds or exploding pods) have a limited success in closed forests so fruit-eating animals are the main distribution agents. These include many birds and mammals, such as possums and bats, as well as some reptiles and fish.

There are two main fruit-eaters — those which depend entirely on fruit for food and those which also eat insects and/or leaves. Plants tend to target either type of fruit-eater.

Some plants, like the lilly pillies (*Syzygium* species), produce large crops of small fruits high in water and sugars. Cheap to produce in large quantities these appeal to the large opportunistic market, including many birds. The fruits are likely to be well distributed but these plants run a few risks. If the consumer is also an insect-eater the seed may be destroyed in the grinding gizzard. If there is an alternative source of fruit or insects the tree may find its fruit is ignored and left to rot.

Other plants aim to attract the more stable but more discriminating specialist market. Animals which eat nothing but fruit are rarer but are more reliable, visiting a suitable fruiting tree repeatedly until the crop is finished. Eating nothing else, they require fruit which provides a balanced diet — one including oil, protein and fat.

High quality fruits are 'expensive' for the plant to produce and are therefore not grown in abundant quantities. However, the risks are fewer, since specialist fruit-eaters (such as the cassowary) generally do not have grinding stomachs and the large seeds pass through unharmed to be deposited some distance from the parent tree in a convenient pile of compost. Alternatively the seed is regurgitated (for example, by bats). If well packaged in firm flesh, which takes time to consume, the seed will first be carried some distance.

The rotting-meat smell of the **bridal veil fungi** is one of the less pleasant aspects of the forest. Flies find it irresistible — and then fly off carrying a load of fungi spores for dispersal.

Mistletoe plants and mistletoe birds have an interesting relationship. The bird eats insects so has a grinding gizzard but is able, when consuming a mistletoe berry, to close the gizzard and shunt the soft (and quite toxic) seed quickly through its digestive tract. Within 25 minutes the seed is voided. It is very sticky so, to get rid of it, the bird is forced to wipe its bottom, and glue the seed, on a tree branch — the perfect germination spot.

The **sticky bean tree** (*Pisonia*) employs rather heavy-handed methods to persuade animals to disperse its seeds mechanically. This small shrubby tree is a common species on coral cays and islands, such as Heron Island. To get there, and to eventually move its species on further, it relies on noddies — seabirds which nest in trees. *Pisonia* seeds are covered with a sticky gum which adheres readily to the plumage of the nesting birds. While a few seeds would not affect the bird too badly, often they become so entangled in seeds they cannot fly and fall to the ground to starve. It has been suggested that the dead bird provides a useful source of fertiliser for the germinating seedlings. Gruesome as the system seems it is an important part of the revegetation of cays and islands — and the noddies in turn rely heavily on the *Pisonia* for nest sites.

Bad relations

A weed is a plant which grows where it is not wanted — and all too often one person's garden glory is another person's headache — particularly when the latter is a national park manager.

On the opposite page we see how the introduction of a South American vine is threatening one of our most spectacular butterflies. Plants can also turn nasty on each other. A notorious example is the rubber vine, introduced from Madagascar in the 1870s for its pretty flower, which has invaded some 350 000ha of Queensland, totally smothering native vegetation in moister sites. A similarly aggressive vine is *Thunbergia grandiflora*. Illustrated with glossy pictures of gorgeous blooms in many gardening books, 'escapees' are doing enormous damage to rainforest in the Cairns area. It is very difficult to destroy. Then there is *Sanchezia*, grown for its yellow-veined leaves. Easily spread by rivers and floods, even small fragments can sprout into new plants. The banks of the North Johnstone River in the Palmerston area were choked with *Sanchezia* — perhaps originating from one garden specimen carelessly tossed in upstream. There are coffee plants, dispersed by birds, and grasses introduced by graziers which, while less spectacularly destructive than the vines, can destroy an ecosystem just as thoroughly. The catalogue of weeds is extensive.

Back home, in their native environment, these plants have natural checks such as insects and diseases. Freed from these restraints they can rapidly invade new areas.

The balance of powers in an ecosystem, particularly in a rainforest, has been finely tuned over a long period of evolution. The introduction of an exotic plant or a feral animal can cause an imbalance which has far-reaching consequences for the whole system; meddle with some of the strands and a whole web may collapse. We hear much of the destruction wrought by feral pigs and cane toads but exotic plants may actually be one of the greatest threats facing rainforests.

Good relations

In your garden, especially if you are involved with accommodation for tourists, consider the advantages of growing **local** native plants. While avoiding introducing weeds which may endanger the very resource which is the basis of the tourism industry of the region, you can attract native birds and butterflies to your property. Tourists attracted by the natural attributes of the area are almost certain to be more interested in unusual local species than in plants such as hibiscus and bougainvillaea which are the humdrum hallmark of every tropical resort the world over.

Facts and stats

on relationships

Lichens consist of two separate plants — an alga and a fungus, whose filamentous roots are woven in a tough skin surrounding the alga. The fungus draws up water and minerals while the alga uses its chlorophyll (green matter) to manufacture food. The fungus also produces an acid which eats into bare rock, providing a foothold (it can produce 1cm of topsoil in about 2000 years!).

Acacias have small nectar-producing glands, (extra-floral nectaries) on their branches. These attract ants which serve to protect the trees from insect attack.

Different species of parasites live on the skins of different species of mammals and can help in identification of their hosts. The discovery of a 100-million-year-old fossil of a type of flea which is today only found on marsupials suggests that marsupials have existed for at least that period of time.

Mammals of the dasyurid (carnivorous marsupial) group — which includes antechinuses, quolls, and others — have a reputation as the meanest on the planet. With cat-like eye teeth and carnivorous appetites, if they are attacked by snakes they are just as likely to counterattack. The presence of many dasyurids in Australia has been put forward as a possible explanation for the high number of venomous snakes (19 of the world's top 23). Quick-acting venoms are the snakes' only defence against a prey which is likely to consume them!

Found in tropical freshwater and mangroves is a fish with dark stripes known as the archer, or more appropriately, the rifle fish. A combination of a ridged tongue and a groove in the roof of its mouth enables it to bring down insects resting or flying above the water surface by shooting droplets at them. To do so accurately it is able to compensate for the visual effects caused by the way light bends as it passes from water to air.

A certain fungus, *Cordyceps*, parasitises insects! Spores from the fungus germinate if they come into contact with certain butterfly larvae which live underground. The fungus then invades the caterpillar's body, and digests it.

Bookshelf

Australian Tropical Rainforests Science — Values — Meaning
L.J. Webb and J. Kikkawa (eds)
CSIRO (1990)
Chapter 7: *The Biological Web — Plant/animal Interactions in the Rainforest*
R.E. Jones and F. H. Crome
Chapter 8: *Plant/insect Interactions - Food Webs and Breeding Systems*
D. Sands and S. House

The Insects of Australia
CSIRO Division of Entomology
Melbourne University Press (1991)
Vol. 1 Chapter 3: *General Biology*
K.R. Norris

An excellent section on insect relationships with plants.

Associations between Insects and Plants
T.R. New
New South Wales University Press (1989)

The emphasis of this book is on insects as predators of plants.

Australian Tropical Butterflies
Peter Valentine and Clifford and Dawn Frith
Tropical Australia Graphics (1988)

Includes information on many of the Lycaenidae which involve themselves with ants.

Butterflies of Australia
I.F.B. Common and D.F. Waterhouse
Angus and Robertson Pty Ltd (1981)

A comprehensive textbook with a good section on biology which includes ant-associations.

Weed Assessment in the Wet Tropics World Heritage Area of north Queensland
Stella Humphries and Peter Stanton
CSIRO and DEH (1992)

Plant Invasions
The incidence of environmental weeds in Australia
Kowari 2
ANPWS (1991)

Wildlife Australia Vol. 27 No. 4 Summer 1990
When the ants get home, they feed their plants
Andrew Beattie and Geoff Monteith

Scientific American Vol. 263 No. 2 August 1990
Seed Dispersal by Ants
S.N. Handel and A. J. Beattie

Ecos No. 53 Spring 1987
Ants and plants — mutualism in action
J. van Schagen

Nature Australia Vol. 25 No. 5 Winter 1996
Land of nectar
Tim Low

Bird-pollinated plants and nectar-feeding birds in Australia.

Australian Natural History Vol. 23 No. 11 Summer 1991-92
A pocketful of mites (domatia)
Dennis J. O'Dowd and Mary F. Wilson

Geo Vol. 15 No. 4 Nov. 1993-Jan. 1994
Settling for a sticky solution (*Pisonia* trees and noddies)
Terence Lindsey and Rod Morris

Tourist talk

ENGLISH	GERMAN	JAPANESE	
symbiotic	symbiotisch	kyo sei no	共生の
interaction	Wechselwirkung	sogo sayo	相互作用
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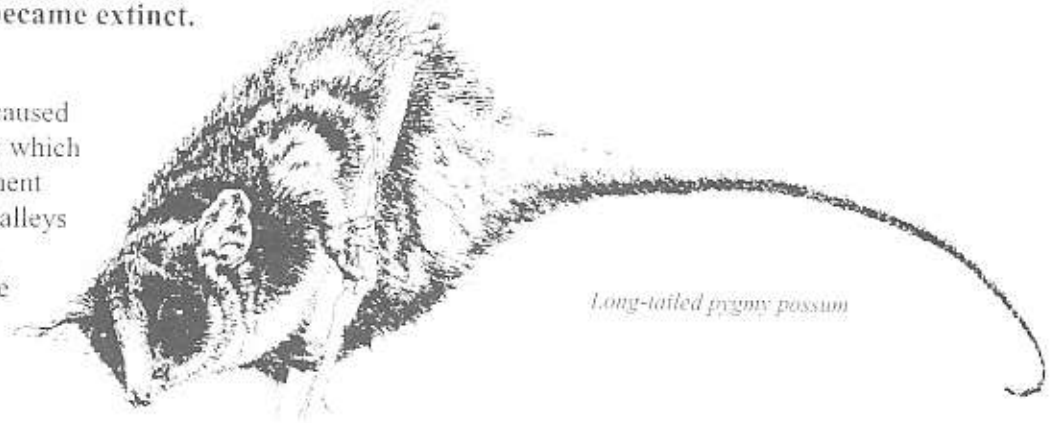
pollination	Befruchtung	jufun	授粉
nectar	Nektar	hana no mitsu	花の蜜
insect	Insekt	konchu	昆虫
toxin	Gift	doku so	毒素
fruit	Frucht	kajutsu	果実

Rainforest possums

Possum patterns

About 15 million years ago Australia, moving north, bumped into the Asian continental plate. This collision allowed an exchange to take place between two sets of flora and fauna which had evolved in isolation. Asian flora and fauna, including many placental rats, moved into Australia. At the same time Australian species moved north. Many animals colonised New Guinea, a new high altitude land mass which had been created by pressure between the Asian and Australian plates. Some, like the Dorcopsis wallaby, thrived in their new home while relatives left in Australia became extinct.



Long-tailed pygmy possum

Changing climatic conditions caused Australia to dry out. Rainforest which had covered much of the continent retreated to 'refugia' — river valleys and cool, moist mountain tops. Then, about 8000 years ago, the climate became wetter and the rainforests expanded again.

Today's Wet Tropics possum distributions reflect these changes. The rainforest ringtails — the green, lemuroid, Herbert River and Daintree River ringtails — remained in the rainforests, retreating with them into the refugia sites and expanding their range again when conditions became wetter. As 'relict' species they have evolved very little and survive in primitive forms.

Other species adapted to the drier conditions; the common ringtail, the brushtail and the sugar glider evolved to survive in open forests. Later, to a certain extent, they re-entered the rainforest to live alongside the relict ringtail species, although they are more commonly seen in open forests.

Because cuscuses (possums related to brushtails) are found only in northern Cape York, they were assumed to have originated in New Guinea, moving to Australia only quite recently. Fossils of ancient (and extinct) cuscuses discovered in Queensland and Victoria, however, turned this story around. It is now believed that these animals were once widespread in Australia but died out, possibly during its driest period about 18 000 years ago. Those which had already moved to New Guinea thrived, two species eventually returning to Australia as conditions there improved.

Working out this ancient puzzle is a slow process and the discovery of different pieces means that the story is constantly being rewritten. Many questions remain. The distribution of the long-tailed pygmy possum, for example, still poses problems because it exists in New Guinea and Australia but is absent from northern Cape York in between. It will be some time before scientists are able to answer all the questions.

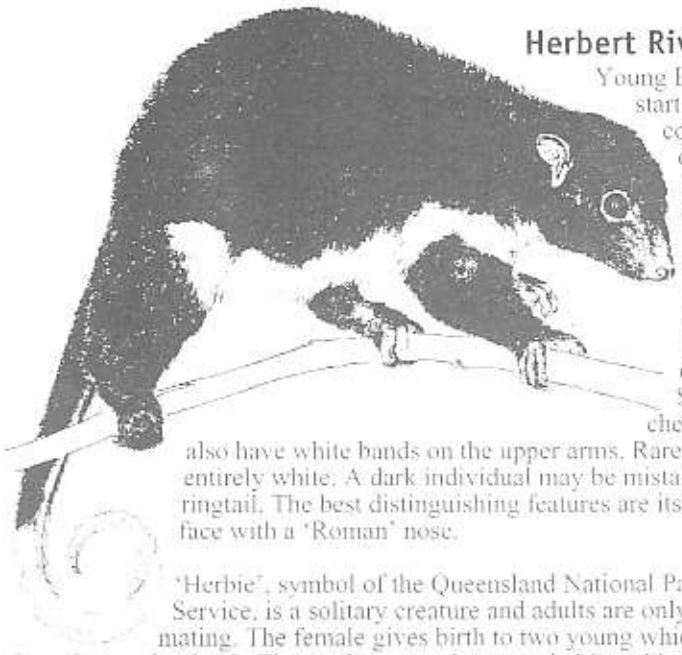
Possums of the rainforest

The Atherton and Evelyn Tablelands, where rainforest exists next to areas of tall open eucalypt forests, is home to one of the largest concentrations of possums in Australia. It is possible (in theory!) to see 13 species of possums and gliders within an area of a few kilometres.

This chapter deals with the rainforest species, specifically the green, lemuroid, Herbert River and Daintree River ringtails, the coppery brushtail, the striped possum and the long-tailed pygmy possum. Some of the open forest possums, notably the sugar glider, do enter the rainforest but there is a fairly clear distinction between rainforest and open forest types.

Possum portraits

Seven possums have their homes in the rainforests of North Queensland. Six of them — the green, lemuroid, Herbert River and Daintree River ringtails, the coppery brushtail and the long-tailed pygmy possum — are endemic to the Wet Tropics and therefore occur nowhere else. (The long-tailed pygmy possum's relative in New Guinea is a subspecies.)



Herbert River ringtail

Young Herbert River ringtails start life with a pale brown coat and a long dark stripe on the head and upper back. Within a year the coat gradually changes. The adult is dark brown, almost black, with varying amounts of white. Most have at least a white spot on the chest and a white tail tip. Some have a pure white chest and/or belly and some also have white bands on the upper arms. Rare individuals are almost entirely white. A dark individual may be mistaken for a lemuroid ringtail. The best distinguishing features are its tapering tail and pointed face with a 'Roman' nose.

'Herbie', symbol of the Queensland National Parks and Wildlife Service, is a solitary creature and adults are only seen in pairs before mating. The female gives birth to two young which spend an unusually short time on her back. The mother sometimes 'parks' her older babies on branches; these should not be moved as the mother will return to them.

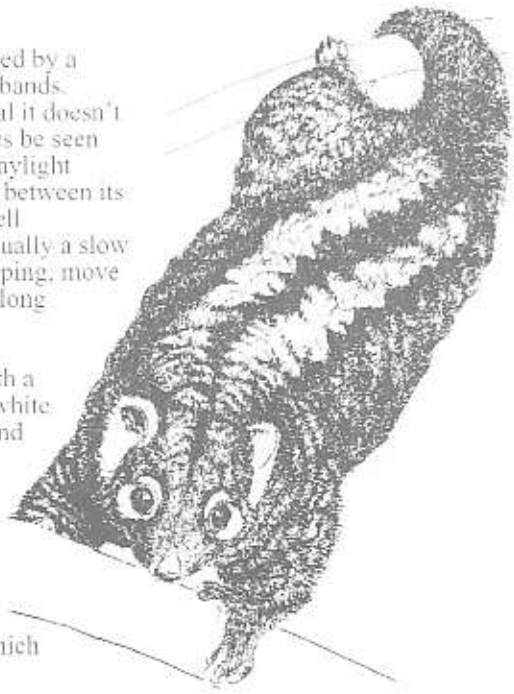
Tree hollows, epiphytic ferns or mistletoes are preferred for dens but some animals have been observed to construct nests, all less than two metres from the ground. Like the common ringtails, the Herbie carries thin branches in its curled tail and weaves them into a cup-shaped or a domed structure with a side entrance.

Daintree River ringtail

This possum is very similar to the Herbert River ringtail but the pale brown colour of the young 'Herbie' is retained by the adult of this species. The two possums have separate distributions, the Daintree species occupying an area to the north of the 'Herbie's' range. They were recognised as different species only in 1989 on the basis of having different chromosome numbers.

Green ringtail possum

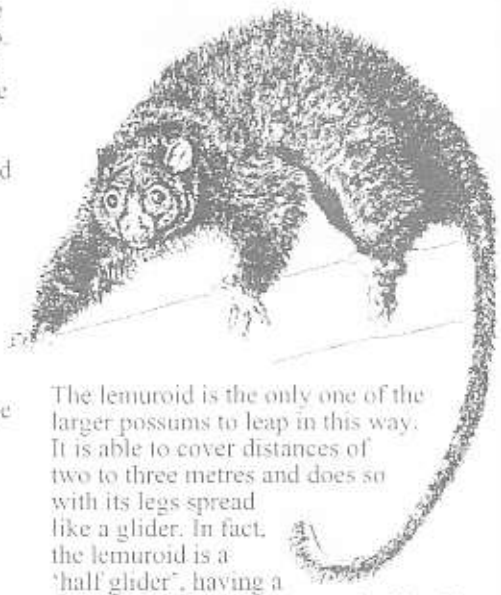
The green of this possum's fur is produced by a combination of black, white and yellow bands. Although, like all possums, it is nocturnal it doesn't retire to a den at night and can sometimes be seen feeding during the day. It spends most daylight hours, however, hunched up with its tail between its legs and curled tightly under its nose, well camouflaged by its fur. Although it is usually a slow mover, the green ringtail can, when escaping, move rapidly through the canopy by running along branches.



The green ringtail has a dumpy body with a pointed face and small ears. Its belly is white and it has white patches under its eyes and ears as well as two silvery stripes along its back. Its tail is thick at the base and tapers to a naked finger-like tip. It is the most solitary of the tree-dwelling ringtails. When two are seen together it is usually a mother with a young one. Although she has two teats, the female usually gives birth to only one young which stays with her for about 10 months.

Lemuroid ringtail possum

This possum was named, in 1884, because its large eyes reminded Swedish zoologist, Robert Collet, of the lemurs from Madagascar which were common in European zoos at the time. These eyes are set to the front of its head and may well give this animal the stereoscopic vision it needs for its free-fall leaps between forest branches.



The lemuroid is the only one of the larger possums to leap in this way. It is able to cover distances of two to three metres and does so with its legs spread like a glider. In fact, the lemuroid is a 'half glider', having a rudimentary skin flap on each side of its body. This is particularly visible in young ones.

The lemuroid characteristically has a round fluffy shape with a short-nosed pug-like face. Unlike other ringtails its tail doesn't taper and is used as a rudder when the animal is leaping. The majority of lemuroids are a charcoal grey to brown colour with a yellowish tinge below. Above 1100m on the Carbine Tableland, however, 30 percent of the animals have white coats. This variation is present in three in 10 000 of the general population; these animals are not a different species but are equivalent of the blonds the among the brunettes!

It is not unusual to see lemuroid ringtail family groups of mother, father and one young together. They usually share the same den site, in a hollow tree, and when disturbed will sit closely together in a tight group. Lemuroids are the most gregarious of the ringtails and sometimes feed in groups of up to eight in one tree.

Coppery brushtail possum

This is the largest of the rainforest possums. A sub-species of the common brushtail which is found extensively over Australia, the coppery brushtail is restricted to the uplands of the Atherton Tableland. Colours vary from grey to yellowish brown to a rich copper, with or without a white tail tip. A grey-coloured animal can easily be confused with the common brushtail but can be identified from its location; if it's in the rainforest it's a coppery and if it's in dry country it's a common brushtail. If confused with its fellow rainforest dwellers, the ringtails, its ears give it away; brushtails have large triangular ears in contrast to ringtails' small rounded ones.

Coppery brushtails are highly territorial, each pair defending their territory from other brushtails, although they usually tolerate ringtails. They use tree hollows as dens and consume a variety of fruits, flowers, leaves and insects. Brushtails move more easily on the ground than many other possums and have the confidence to scavenge around picnic grounds and in rubbish bins and to approach people for food.

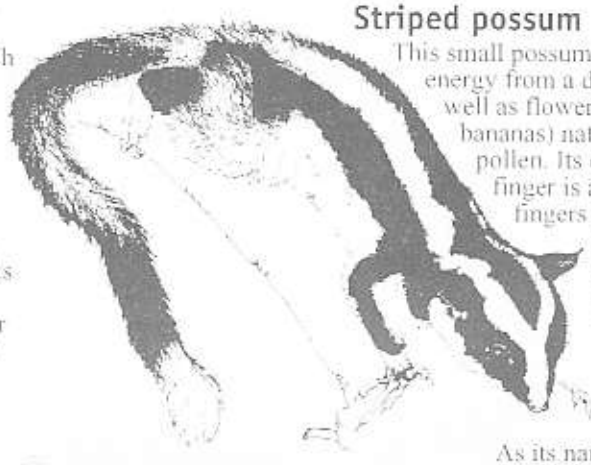
Long-tailed pygmy possum

This tiny possum has a body only 10cm long. It has a black patch around each eye, crinkled ears and a furred base to its tail. It is similar in size to a mouse or rat but can be most easily distinguished by its typical possum hind feet with two grooming toes and opposable thumb. Its tail, which is often tightly curled, is one and a half times the length of its body. It has a bumpy appearance due to the long bones under the thin skin which show a change in angle between each segment. The little possum can hang from a branch and then climb up its own tail.

Favourite food includes nectar, pollen and insects. Up to three or four have been found feeding on the trunk-flowering bumpy satinash (*Syzygium cormiflorum*) but the long-tailed pygmy possum is generally solitary. It constructs a spherical nest from leaves or fern fronds, in a tree hollow, hollow stump or clump of ferns. Females share their nest with up to four young. Adults (but not couples) also sometimes share.

Occasionally a possum has been found in a torpid state on a cold winter day; the animal is stiff and cold with limp ears and lips drawn back from the teeth as if it is dead. This is probably an energy-saving strategy and it becomes active again after dark.

Striped possum



This small possum gets its frenetic energy from a diet of insects as well as flowers, fruits (including bananas) native bee honey and pollen. Its elongated fourth finger is almost twice the length of other fingers and is used to probe rotten wood for beetle larvae while its chisel-like teeth are used to rip open dead wood. In fact, the noise of these activities may first alert the observer to its presence. During the day the sight of scratched and ripped forest logs indicate that striped possums are around.

As its name suggests, the striped possum has unmistakable black and white stripes along its body. It is long and slender with a long bushy tail and a head which looks large in relation to its body. It has a very strong, musky smell which may make it distasteful to predators in which case its striking coat, instead of making it vulnerable, may function as a highly visible warning.

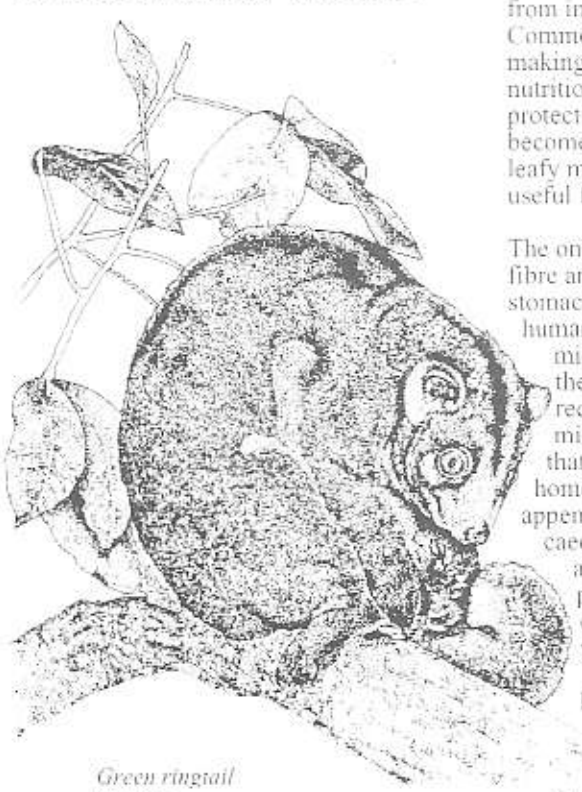
Although a rainforest dweller, the striped possum will venture up to several kilometres into nearby open forest. It is a fast, agile climber and makes leaps of one to two metres. Usually solitary, the striped possum uses holes in trees for its den, lining them with leaves which it carries in its curled tail.

Where are they?

Ringtails and coppery brushtails are all found in the upland rainforests of the Wet Tropics. The green ringtail is the most widely distributed, and is found between Mt Misery in the north and the Paluma Range in the south. The lemuroid is found from the Carbine Tableland to the Cardwell Range. The Herbert River ringtail is distributed between the Lamb Range, near Cairns, and the Seaview Range, north of Townsville, while the very similar Daintree River ringtail is found to the north, from Thornton Peak (Daintree) to the Carbine Tableland. Although these ranges seem quite extensive, as these possums are upland dwellers (above 300-450m) many exist only in isolated populations on mountain tops.

Only the long-tailed pygmy possum and the striped possum are found in lowland as well as upland forests. The striped possum is widely (but sparsely) distributed, from Mt Spec to the tip of Cape York and into New Guinea. The long-tailed pygmy possum is found from Daintree to the Paluma Range and in New Guinea. Its apparent absence from Cape York may be because it simply hasn't been recorded there.

Diets and dens



Green ringtail possum

The rainforest ringtail possums are primarily leaf eaters, taking an occasional snack of flowers and fruits on the side. Not all leaves, however, are edible.

As leaves are a plant's solar cells, essential for survival, plants protect them from insect and mammal predators. Common protection methods involve making the leaves poisonous, non-nutritious and/or tough. To counter these protection strategies, animals have become very selective in choosing their leafy meals and have also cultivated some useful friends – gut microbes.

The only organisms able to digest plant fibre are special microbes found in the stomachs of all animals, from termites to humans, which eat plants. Certain micro-organisms can also break down the poisons found in leaves but this requires a lot of energy. These useful microbes are so important to possums that they have provided a special home for them, the caecum. The human appendix is the equivalent of the caecum. However while the human appendix is small (we don't rely on plant fibre to survive), the possum's caecum is large, reflecting its vegetarian diet.

Research has found that not only are possums very selective eaters, but their behaviour also depends largely on the energy available in their diet. Lemuroid ringtails choose leaves low in fibre such as the young leaves of Queensland maple (*Flindersia brayleyana*) and white carabeen (*Sloanea langii*). Because they use less energy to digest their food they have more to spend. This species is therefore the most energetic of the three ringtail possums, leaping between trees and returning to a fixed den at the end of the night's activity.

In contrast to the lemuroid possum, the green ringtail is the sloth of the rainforest. Its diet consists of tough and poisonous fig leaves, the leaves of some laurels and even those of the shining stinger! Such a diet is low in energy but easy to find, because there are few other animals wanting to eat such poor quality food. Green ringtails therefore do not have to search far for something to eat. Then, at the end of the night, these low-energy possums save on fuel by curling up wherever they are. Consequently, green ringtails don't have a fixed den but change their sleeping site nightly, depending on the location of their last meal.

Herbert River ringtails feed on regrowth species such as sarsaparilla (*Alphitonia petriei*) and quandongs such as *Elaeocarpus ruminatus*. Their energy intake falls somewhere between that of the green and the lemuroid ringtails, and so does their den requirement. 'Herbies' will return to dens if they are close to home at the end of the night's activities. Otherwise, they will not waste energy and often prefer to camp in nearby epiphytic ferns.

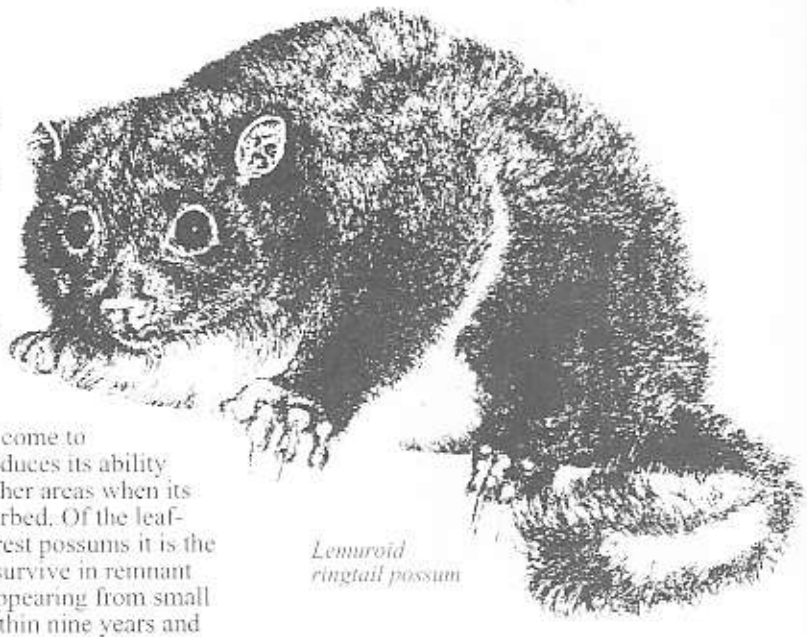
Acknowledgments to Dr Nicky Goudberg.

Possums and patches

Research shows that different species of possums can co-exist in the same area of rainforest by feeding on different plants. This variation in diet, and related lifestyle, leads to different responses to destruction and fragmentation of forest.

Green ringtails and coppery brushtails are the most adaptable and can be found in quite small patches of forest as well as in disturbed areas. These animals feed on secondary growth and pioneer species which commonly result from disturbance, as well as species such as fig trees which are not removed by loggers. They are also willing to travel along the ground, even through open areas away from rainforest, enabling them to move between small forest patches. The green ringtail is not dependent on den sites such as tree hollows or epiphytic ferns.

Lemuroid ringtails and Herbert River ringtails are more vulnerable. The lemuroid is a high canopy dweller which never comes down to the ground. Unfortunately its diet consists largely of mature rainforest tree foliage, particularly those cabinet timber trees which are the target of loggers. It needs a den for daytime resting and does not live in secondary forest. Its reluctance to come to the ground reduces its ability to move to other areas when its home is disturbed. Of the leaf-eating rainforest possums it is the least able to survive in remnant patches, disappearing from small fragments within nine years and from fragments of 40-80ha within 35-60 years.



Lemuroid ringtail possum

The Herbert River ringtail has similar dietary and den requirements to the lemuroid but is able to feed on some secondary trees. It is less of a canopy dweller and will come to the ground, enabling it to escape from areas which are disturbed. Numbers decline sharply in areas under 20ha in size.

Acknowledgments to Dr Bill Laurance

Possum tucker

Possum's got a belly ache
Positively crook
Spare a thought for possum's sake
'Cos possum's not a sook

Possum lives on forest food
Not on tourist snacks
Possum doesn't feel too good
It's sympathy he lacks

Possum lives in possum land
A finely balanced state
Feeding possum from the hand
Endangers possum's fate

By all means look and listen
And savour possum's play
But keep the tucker hidden
Let possum live his way!

Robin Filkin

Possums and humans do not have the same digestive systems. If fed a diet of leaves our health would suffer. Similarly, possums cannot cope with bread and other 'human' foods. They might as well be eating cotton wool. It makes them feel full so they eat fewer leaves, causing malnutrition and ill health.

Feeding possums not only leads to a dependence but can also change population balances. Generally it is the brushtails which will approach humans for handouts. This artificial increase in food supply leads to a population boom in that particular species. Other types of possum are pushed out of the area and the diversity of species decreases.

Unnaturally tame possums which have become accustomed to coming down to the ground for food are also in danger from dogs. If you *must* feed a possum, please give it fruit or carrot (avoid cabbage and other brassicas). However, with a little effort, careful spotlighting will reveal a greater variety of possums without damaging the animals. Bear in mind, also, that feeding of animals in national parks is illegal.

Spotlighting for possums

As possums are nocturnal animals, the best way to find them at night is to look for their eyeshine with a spotlight. Eyeshine is caused by a membrane, or 'tapetum', at the back of the eye which reflects light back through the eye a second time to enhance night vision. The more reflected light — in other words, the brighter the eyeshine — the better the animal can see at night. Thus our dull red eyeshine, seen in flash photos, reveals our night vision to be inferior to that of the cat, with its bright white glare.

Rainforest possums also have different coloured eyeshine depending on the species. With practice the colours and brightness can be used to help identify the different species; lemuroid ringtails have the brightest eyeshine — a brilliant white/yellow glare — Herbert River ringtails have a pink/yellow eyeshine, green ringtails a dimmer red eyeshine and brushtails and striped possums have a pinkish eyeshine. Sometimes the colours appear different if the animals are not looking straight at you or if they are juveniles, so use the eyeshine merely as an indicator.

Thoughtless spotlighting can cause distress to animals. Night-adapted eyes are very light sensitive so avoid 100 watt spotlights. Although eyeshine can be picked up with a small torch, to view the animal a 30 watt spotlight (in conjunction with binoculars) is best. Always place the spotlight directly in front of your face so you can look along the beam, otherwise you often miss the eyeshine. Once an animal has been located and identified, swing a red filter, such as a single layer of red cellophane, over the white light. Although this dims the light a little, possums are far less disturbed by the red light and will continue their activities while you watch. Their reactions to white light can vary from prolonged grooming, which is a sign of nervousness, to moving away completely. Usually animals become less light-tolerant as the evening progresses.

While looking for animals try to remain quiet — often sounds of activity guide you to an animal. Likewise, keep quiet while watching. Repeated disturbance scares animals away from an area and makes finding them difficult for everyone.

Acknowledgments to Dr Nicky Goudberg.

Facts and stats

on possums

Predators on possums include owls (sooty and rufous) as well as pythons (particularly carpet pythons) and, possibly, spotted quolls.

Ringtails are very quiet animals, the adults generally remaining silent while the young may produce a quiet noise when separated from their mothers. Coppery brushtails make more noise while striped possums are the most vocal, producing a variety of harsh growling calls and loud shrieks while mating. Their presence is also indicated by their noisy and messy eating habits rustling, scratching, snorting, slurping, chewing and falling debris!

A ringtail's tail is prehensile and can be used as a fifth limb. When it is not in use it keeps it neatly curled up. A brushtail's tail is only moderately prehensile so it's not so useful.

Ringtails have large sharp teeth which cut and grind leaves efficiently. Green ringtails, particularly, have enormous salivary glands with a buffering solution which allows them to deal with the many toxic leaves in their diet. This possum's food is so low in energy it eats its own faecal pellets, thus digesting the same material twice!

Striped possums have been seen tapping branches with their front feet when searching for food. This tapping may reveal hollow parts of the wood where beetle larvae are to be found.

The green ringtail, when disturbed at night, will curl up and sit motionless for hours staring calmly down at the intruder. Presumably this strategy conceals it from most predators. However, it can move quickly, often as soon as the observer turns away.

Bookshelf

Spotlight on Possums
Rupert Russell
University of Queensland Press (1980)

This delightful book is based on the author's fieldwork around the Atherton Tableland. It is a personal, anecdotal and informative account of most of the Wet Tropics possums and gliders and is superbly illustrated. Happily we have been given kind permission to reproduce some of the illustrations in this chapter.

Complete Book of Australian Mammals
Ronald Strahan (ed)
Angus and Robertson Publishers (1995)

This book provides an account of every species of native mammal known (in 1995) to have existed in Australia since European settlement and every introduced species now living in a wild state. There are several chapters on possums (Wet Tropics species and others). Each species is described and illustrated with excellent photographs over two to three pages. A statistics section gives details of size, identification, status and so on.

Rainforest Animals
Atlas of Vertebrates Endemic to Australia's Wet Tropics
H.A. Nix and M.A. Switzer
An Australian National Parks and Wildlife Service Publication
(Kowari 1) (1991)

Five endemic possums are included in the mammal section (the coppery brushtail has not been included, perhaps because of its close relationship to the common brushtail). For each there is a picture, a map showing recorded and predicted locations, a description and data on its range. The chapter has an introduction by John Winter which mentions possums in conjunction with other mammals of the region.

Australian Natural History
Vol. 21 No. 1
Charming ambassadors of our northern forests
Possums of Australia Part 2 - the north
John Winter

This very interesting, informative and readable article concentrates mainly on rainforest species and the cuscuses of Cape York with a mention of the gliders of the open forests.

Nature Australia Vol. 25 No. 5
Winter 1996
Possum patterns plucked from stone
Michael Archer

A look at the implications of the author's discovery of an ancient cuscus fossil in Queensland.

For the academics

Possums and Gliders
Andrew Smith and Ian Hume (eds)
Surrey Beatty and Sons Pty Ltd
(1984)

Possums and Gliders
Studies in Evolution
Michael Archer (ed)
Surrey Beatty and Sons Pty Ltd
(1987).

Tourist talk

ENGLISH	GERMAN	JAPANESE	
possum	Opossum	fukuronezumi	フクロネズミ
tail	Schwanz	shiipo	尻尾
ears	Ohren	mimi	耳
eyeshine	Augenglanz	ganquuhanshya	眼球反射
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Cassowaries

Gardeners of the forest

How did the mango trees get to the top of Mount Whitfield, in Cairns? In their natural home, India, monkeys and elephants eat the fruits and carry the heavy seeds to spots where they can germinate. Without these animals the trees could only migrate downhill as the force of gravity moved the fruits. How then did the seeds get to the top without the help of monkeys or elephants? Although flying foxes or bushwalkers may have been responsible, the cause was probably cassowaries.

Some fruit-eating birds use grit in their digestive systems to break up the more protein-rich seeds as well as the less nutritious flesh. Cassowaries, however, have a 'gentle' digestive system which passes the seeds, unharmed and often with flesh still attached, into a pile of compost. The smell from the pile apparently protects the seeds from predators such as white-tailed rats, while keeping the seeds moist. In this way the cassowaries 'cultivate' the forest, dispersing only those seeds which are useful to them.

It has been estimated that seeds remain in a cassowary's gut for 10 hours or longer. At a slow pace the bird could cover as much as 30-40km before expelling the seeds so, at the very least, it is likely to carry them a few kilometres. As many of the rainforest fruits are large they are unlikely to be moved far by any other animals, except, perhaps, flying foxes. It has been estimated that 70 to 100 species of plant depend almost entirely on the cassowary to disperse their seeds. This means that the bird plays a key part in the ecology of the rainforests of the Wet Tropics and there is growing concern that as cassowaries disappear the forests will lose many species of plants as well as the other animals which, in turn, depend on them.

Tragic loss

The last known cassowary on Mt Whitfield died, tragically, on 2 November 1996, when attacked by two dogs. Blue Arrow, as she was sometimes called, had earned a reputation for pursuing walkers on the Mt Whitfield track. Having been thoughtlessly fed by people she had come to associate humans with food and to demand it, with persistence, her large size adding weight to her argument.

Eventually Blue Arrow moved down the hill where she found more humans willing to feed her — she died with pieces of apple in her stomach. Thus encouraged to remain in the area, her death was almost inevitable, either on the road or, as it turned out, by dog attack.

Number one bird in danger

Participants in a Wet Tropics Community Attitudes Survey were asked the question 'What particular plant or animal do you associate with the Wet Tropics World Heritage Area?' Of those surveyed, 37 percent nominated the cassowary. The decisiveness of the survey (ferns, which came second, polled only 14 percent of the votes) showed that the largest and most spectacular vertebrate of the Wet Tropics forests holds a special place for its fellow (human) inhabitants.

Unfortunately the cassowary is threatened. A 1988 CSIRO survey found that the population had declined and a more recent survey is not encouraging. It is thought that numbers now total less than 1500 in the Wet Tropics and the bird's status, under Queensland law, has been changed from 'vulnerable' to the more threatened category of 'endangered'. This means that it is 'in danger of extinction'. With rapid deforestation in New Guinea, it is particularly important that we in Australia protect this extraordinary bird.

Candid cassowary

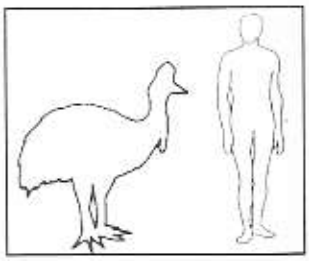
The name cassowary comes from two Papuan words, *kasu* which means horned, and *weri* which means head. There are three species of cassowary in New Guinea, one of which is also found in Australia — *Casuarius casuarius*. The distinct Australian subspecies is known as *C.c. johnsonii* — the southern, or double wattled, cassowary. (Fossil records show that a dwarf cassowary also existed in Australia when conditions were moister.)

Family

The cassowary is a member of the ratite family, one of the most primitive groups of birds, which includes the flightless kiwi, emu, ostrich and rhea as well as extinct species such as the elephant bird of Madagascar. Cassowaries and emus are closely related. It is thought that they both evolved from forest-dwelling ancestors and that the strong running legs of the emu developed later.

Size

An adult cassowary can reach 1.8-2m in height although most are about 1.5m. Females are bigger than males. The largest on record weighed 85kg, making it Australia's largest land animal. Weights of 60kg are not unusual for females while males weigh in at 35kg.



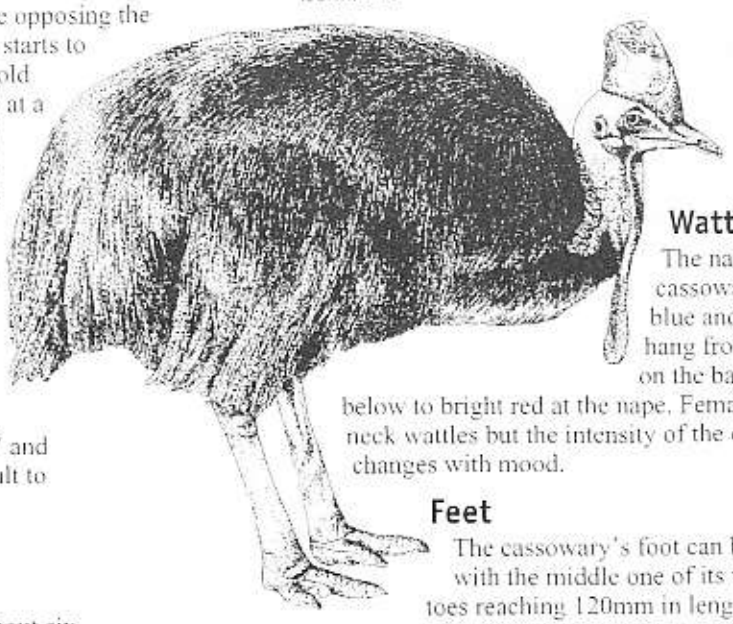
Casque

The casque is not, as sometime stated, horny or bony or a protuberance from the skull, but a tough keratinous skin covering a core of firm, cellular foam-like material (similar in structure to styrofoam). It is longtitudinally rigid but can be squeezed at the sides.

Elastic and resilient, the casque would certainly be a good shock absorber but opinions differ as to whether it is a crash helmet or an indicator of age and dominance. Those opposing the crash helmet theory point out that it only starts to develop in young birds of 18-24 months old which means they are without the casque at a stage when they are particularly prone to damage. In any case, if a cassowary was crashing casque first through the forest it would be unable to see where it was going! Casques can be bent, tilted or grooved, these characteristics helping to identify individuals.

Voice

Cassowaries make a variety of noises. One may produce a rumbling when approached in the forest. Then, when threatened, it may stand upright with plumage raised to give as large an impression as possible and hiss in its throat. When it is very angry and/or about to attack it puts its head down with the bill pointing to the ground and produces a deep booming noise. At the same time the colourful skin inflates and its body trembles.



Wattles

The naked skin around the cassowary's neck is bright blue and a pair of red wattles hang from the front. The blue on the back of the neck grades below to bright red at the nape. Females often have brighter neck wattles but the intensity of the colour in all birds changes with mood.

Tails

Male birds have a slightly drooping 'tail' and females have none. However, it is difficult to tell the sexes apart.

Feet

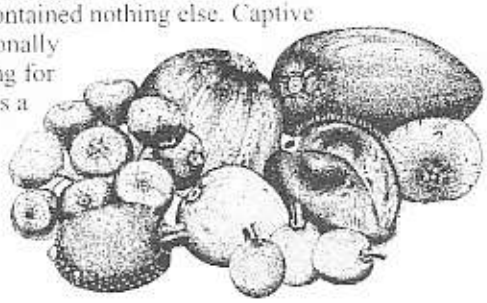
The cassowary's foot can be up to 180mm long with the middle one of its three forward-pointing toes reaching 120mm in length. When confronted, the bird can use them as a weapon, jumping up and kicking forward with both feet at once.

Wings

The cassowary's wings are reduced to about six long quills which curve round the side of the body, probably serving to protect its body as it moves through rainforest vegetation.

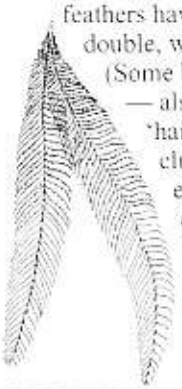
Food

Apart from forest fruits, cassowaries also eat snails, insects, fungi, flowers and some dead animals. Captive birds have been fed live and dead mice and have been known to catch, kill and eat birds. Although a small part of their diet, these protein supplements may be important additions to low-nutrient fruits. At times of food shortages some birds eat earth — some droppings have contained nothing else. Captive birds have occasionally displayed a craving for it. Presumably it is a source of minerals.



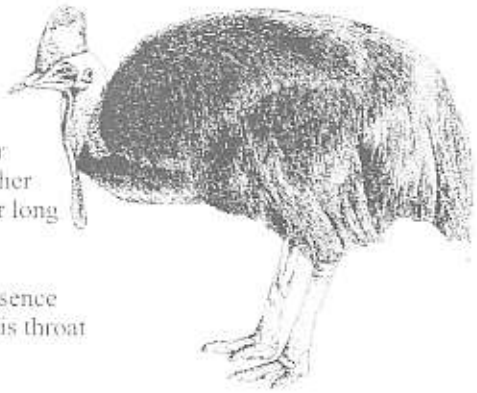
Plumage

Unlike the plumage of most other birds, the cassowary's feathers have no barbs and very little down. Each feather is double, with a secondary shaft sprouting from the base. (Some birds — grebes, pheasants and some song birds — also have 'aftershafts'.) The result is a stout 'hairy' coat which may allow the bird to escape the clutches of 'wait-a-while' (lawyer cane) more easily than most! Unlike other birds the cassowary has no oil glands to groom and waterproof the feathers. Some feathers may provide a powder for this purpose, as is the case with pigeons.



Encounters

For most of the year cassowaries are solitary creatures. If the dominant female encounters a male out of the mating season she stretches up and stares silently at him whereupon he flees. Fighting cassowaries raise their feathers and, bending their necks right under their bodies, roar loudly. They then charge at each other kicking with both feet. However, they do not usually fight for long and little damage is done.



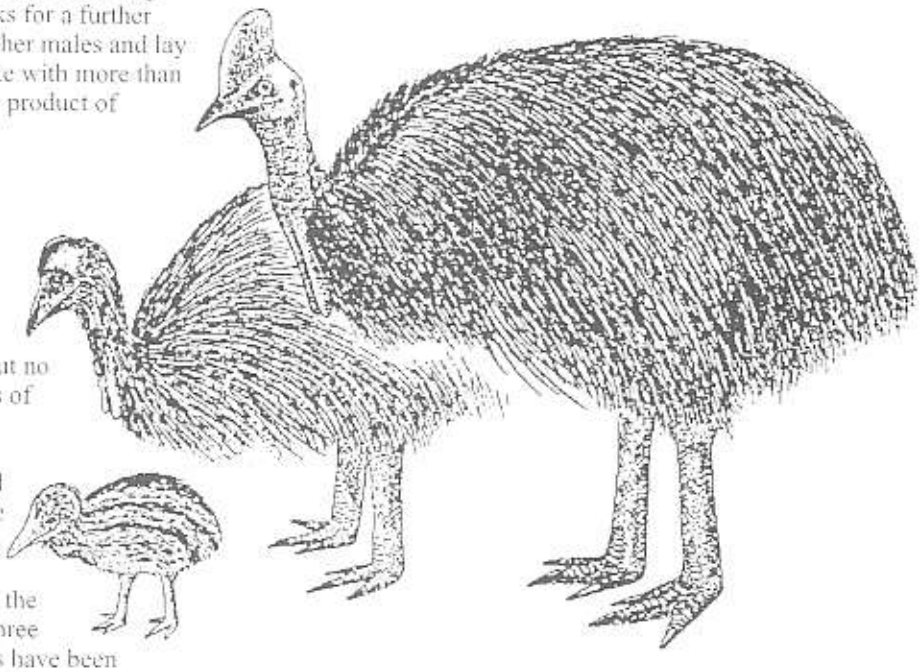
In the breeding season the female usually tolerates the male's presence eventually. Before mating the male moves around the female, his throat trembling and swelling as he makes a low rumbling noise.

Nests

Clutches usually consist of about three to five eggs (up to eight have been recorded). Each egg weighs 500-600g (equal to about 10 domestic chicken's eggs) and is pale green with an uneven surface. The female deposits them in a scrape in the ground lined with grasses, leaves and ferns. Afterwards she departs, leaving the male to incubate the eggs and raise the chicks for a further nine months. The female may then mate with other males and lay more clutches. However, the male may also mate with more than one female so the eggs in one clutch may be the product of different mothers.

Chicks

The male sits on the eggs for about 50 days, seldom leaving the nest, except to drink, during that time. He constantly turns the eggs. The newly hatched chicks are striped black and cream with pale brown heads and tiny wattles but no casque. The male is very protective and in times of danger the chicks hide under his tail.



At about three to six months the stripes fade and by the first year the chicks are a dull brown. The skin around their necks begins to colour at about six to nine months. At this stage, the beginning of the new mating season (June-Oct), the male chases his chicks away. It will take them three years to acquire full adult plumage. Cassowaries have been known to live up to 40 years (in captivity) while there are unconfirmed reports of individuals reaching 60 in the wild.

The cassowary year

January — March

Adult males are seen with large young while females are solitary.

Birds roam extensively because food is scarce and eat almost anything they can find, including dried droppings.

April — June

This is still a difficult time for the birds. Adults begin courting in May/June and the young are evicted from the home range. This is a hazardous time for immature birds learning to fend for themselves in competition with intolerant breeding adults. Many juveniles die during this period.

July — September

Fruiting trees in the lowlands are producing reliable food — many favoured species are in full fruit at this time.

Eggs hatch during the maximum fruiting period. Males are very protective of their chicks and human contact should be avoided.

October — December

Males are moving around with their striped or brown young while the more colourful females make occasional appearances. There is no shortage of food. This is a very important period when birds build up reserves to cope with inevitable shortages in the new year.

Acknowledgments to the Community for Coastal and Cassowary Conservation (C4)

Where are they?

Cassowaries are widely but patchily distributed in a narrow strip on the east coast between Townsville and the tip of Cape York. In the past they probably occurred in relatively high densities between the Russell and Murray Rivers but much of this land has been cleared for agriculture. There may now be fewer than 1500 cassowaries with concentrations at Mission Beach, Woopen Creek, Graham Range, Coquette Point and Wallaman Falls.

It has been suggested that different genetic populations may exist but the birds would have to be tested to verify this.

Cassowary homes

© Aussie nomad

Cassowaries are associated with rainforest but many move into other habitats which are important sources of food at certain times of year. A mosaic of vegetation types may be the ideal habitat.

The birds tend to be solitary and operate within a home range which changes in size and shape according to season, food availability and whether the cassowary is caring for chicks or not. Female territories may be surrounded or overlapped by male territories through which the females are allowed to wander at will. On the other hand, males defend their territories from each other.

Generally adult cassowaries avoid each other. Although it is not unusual for several individuals from adjacent territories to visit an abundantly fruiting tree, they will manage to do so at different times. However, cassowaries have been known to congregate at times of food shortages, such as in the aftermath of Cyclone Winifred in 1986.

Food shortages occur in most years. There is a general pattern of peaks and troughs with weather acting as the main environmental trigger for flowering and fruiting. However, events such as cyclones can disrupt this pattern. Water is also very important. Cassowaries need to drink frequently and in areas of recent clearing have been observed crossing open paddocks to reach watering points. At Edmund Kennedy National Park 13 cassowary territories overlap at a swamp area, possibly the only permanent water source.

Cassowary corridors

The biggest threat of extinction comes not from direct actions of humans or other species but from loss of habitat. Any species which becomes isolated is vulnerable. An accident such as fire, drought or cyclone which devastates a local population is not a disaster if more animals can then repopulate the area but if they are isolated it could lead to permanent local extinctions. It is also important for populations to mix to maintain genetic diversity.

Human activity has had its greatest impact on cassowaries by isolating them in forest 'islands'. The most important thing we can do is to stop clearing and retain any remnant pockets of original vegetation. These often act as stepping stones enabling larger areas to be used. We can also plant corridors of vegetation linking these pockets of vegetation. We know that although cassowaries will cross open paddocks, they will more readily use vegetated corridors.

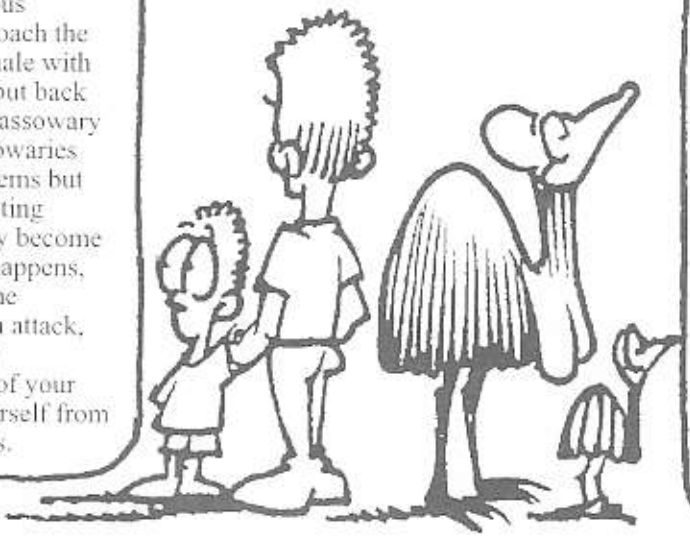
An information sheet on *Cassowary food plants for revegetation*, listing a number of important plants, is available from some Department of Environment offices. If you (or friends) have a block of land which could be used by cassowaries you might like to grow some of these plants*. Please note, however, that cassowaries prefer the safe cover of weedy scrub to a neat well-mown plantation of young trees. Removing a protective cover in order to plant 'cassowary trees' could actually be more detrimental to the immediate well-being of the animals! It would be better to add existing scrub than to remove it.

Cassowaries need a variety of plants which fruit at different times of the year. Studies have shown that members of the Myrtaceae family provide about 30 percent of the cassowaries' food but these fruits are low in nutrients. On the other hand members of the Lauraceae family, though making up only 19 percent of the diet of the cassowaries studied, provide much more nutritious fruits and are very important. Lawyer vine can be vital in times of shortage and made up 11 percent of the food source of the birds studied.

**Even if you don't live in an area where cassowaries are likely to roam, consider native plants for your garden. Many will attract other birds and butterflies. There is a fascinating variety and planting them will help you learn much more about our native flora.*

Beware

If you meet a cassowary in the wild remember that it is an unpredictable and potentially dangerous animal. Don't approach the bird, especially a male with chicks. Don't run, but back away keeping the cassowary in sight. Most cassowaries will cause no problems but one which is protecting young or a nest may become aggressive. If this happens, back away and in the unlikely event of an attack, be prepared to hold something in front of your body to protect yourself from the bird's sharp toes.



Cars are unpredictable and potentially dangerous things. Sometimes they halt and produce an instant harvest of fruit. On other occasions they continue their speedy forward motion and can injure and even kill cassowaries. Do not approach a car, especially one which is moving. Don't run in front of one but return quickly to the forest. It has been suggested that if you frequent a car track that one will inevitably stop and produce fruit. On the other hand, since the majority of cassowaries are killed in this way, it is definitely best to avoid these areas completely.

Cassowary casualties

Natural predators of cassowaries include crocodiles, pythons, dingos, and native cats. However, the effects of these animals are minimal when compared with threats introduced over the last two hundred years.

Pigs are a big problem. They probably destroy nests and eggs but their worst effect is as competitors for food which could be catastrophic for the cassowaries during lean times. They also use and contaminate water sources. Dogs are a major risk. An adult cassowary could usually get the better of a single dog but young are at risk and even older birds succumb to packs of dogs. Dogs also chase the birds away from potential food sources in suburban areas.

A number of cassowaries are illegally shot each year. Some are killed because of unjustified fears for fruit crops. Others are shot through fear or, unbelievably, for fun.

In a survey of 24 known cassowary deaths in the Mission Beach area between February 1986 and September 1988, only two were attributed to natural causes, namely disease. (There are growing concerns, however, that diseases are being spread to the birds from domestic animals.) Five were the victims of dog attacks and 17 died as a result of road accidents — the greatest single cause of death. Roads cut through their habitat making it necessary for the birds to travel across them when moving around looking for food. Unfortunately people often hand feed the birds from cars thereby attracting them to the roads sometimes with fatal results.

Through the efforts of the Community for Coastal and Cassowary Conservation (C4) at Mission Beach, road deaths have now been reduced to an average of two a year. Strategies include media releases and signs erected at current cassowary road crossings.

Road accident victim. Illustration from photo.

If you find an injured cassowary, please call the Far North Queensland Wildlife Rescue Association's emergency number: 015 962 075

Facts and stats

on cassowaries

Cassowaries are good swimmers and can cross deep rivers. It is also possible that cassowaries enter the water to go fishing. A nineteenth century scientist observed a Bennet's cassowary in New Guinea immersing itself in a river with its feathers spread. After 15 minutes it closed up its plumage and walked on to the bank. It then shook its feathers and ate several fish which dropped out! There is also one report of this happening at Mission Beach after Cyclone Winifred. It is quite possible that the cassowary's feathers resemble water weed in which the fish normally hide.

The first cassowary seen in Europe arrived in Amsterdam in 1597 having been given to a Dutch sea captain in Banda (Indonesia).

The last recorded human fatality in Australia was a 16-year-old boy near Mossman in 1926. While running away from a bird which he (and/or his dogs) had been trying to attack he tripped and fell. The cassowary ran over him, unfortunately severing his jugular vein with its foot. Deaths in New Guinea are more common.

CSIRO scientists studying cassowaries discovered that of the 78 plant species they found in cassowary droppings, 70 species germinated. It has been suggested this success may be because something in the cassowary's digestive system removes a germination-inhibitor or breaks the seed coat down.

In New Guinea cassowaries are used by some groups to settle disputes. Traditionally opposing parties settled arguments with 'races', or competitions which involved killing equivalent numbers of pigs until one side ran out of stock. In relatively recent years cassowaries were introduced as items with rarity value. (Over 40 cassowaries were killed at a race north of Mendi in 1974.) The value of a cassowary has been equated with eight pigs or one woman!

Cassowaries were a traditional food for Aborigines. Explorers with the Kennedy expedition of 1848 shot one and 'the flesh was eaten and found to be delicious; a single leg afforded more substantial food than 10 or 12 hungry men could dispose of at a single meal'.

Bookshelf

Very little has been published on cassowaries although, of course, all Australian bird books mention them.

Cassowary
Australia's endangered rainforest inhabitant
Christina Dwyer
Broad Books

This colour booklet covers much the same ground as this chapter with more detail and colour photographs. It is written in a simple style which would make it particularly useful for children.

Reader's Digest Complete Book of Australian Birds
Reader's Digest Services Pty Ltd

This comprehensive bird book has a good page of information with coloured photos.

Australian Tropical Rainforests
L.J. Webb and J. Kikkawa (eds)
CSIRO (1990)
Chapter: *The Biological Web — Plant-Animal Interactions in the Rainforest*
R.E. Jones and F.H.J. Crome

The first part of this interesting chapter examines the relationship between plants and fruit-eating seed dispersers, including, of course, the cassowary. (The chapter then looks at pollination and leaf-eating animals.)

Cassowary contacts

A number of organisations have been set up to study cassowaries and assist in their conservation.

The Community for Coastal and Cassowary Conservation (C4)
PO Box 165
Mission Beach, QLD 4852
Tel: (07) 4068 7197
Fax: (07) 4068 7298
Email: c4@iig.com.au

Daintree Cassowary Care Group
PO Box 871
Mossman, QLD 4873
Tel: (07) 4098 9171

There are several places where you can find out more about cassowaries. The Community for Coastal and Cassowary Conservation (C4) runs the Environment Information Centre and Theatrette at the Wet Tropics Information Centre, Porters Promenade, Mission Beach. It is not far from the town centre — follow the signs.

Also at Mission Beach, there are two interpretive walks at the Tam O'Shanter State Forest. One, at Lacey Creek, is a 1.1km loop track from the carpark through cassowary habitat. There is trackside information and a cassowary information shelter. The other, at Licuala Park, is a 350m children's cassowary trail. Concrete cassowary footprints lead the children to a model nest with four (fake!) eggs. There is also a special children's brochure.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
cassowary	Cassowary	hikui dori	火喰い鳥
casque	der Helm	kabuto jou no mono	かぶと状の物
feet	Füße	ashi	足
feed	füttern	tabemono o ataeru	食物を与える
fruit	Obst	kajitsu	果実
female	weiblich	mesu	雌
male	männlich	osu	雄
incubate	brüten	fukasuru	ふ化する
dogs	Hunde	inu	犬
road	Straße	doro	道路

Bats

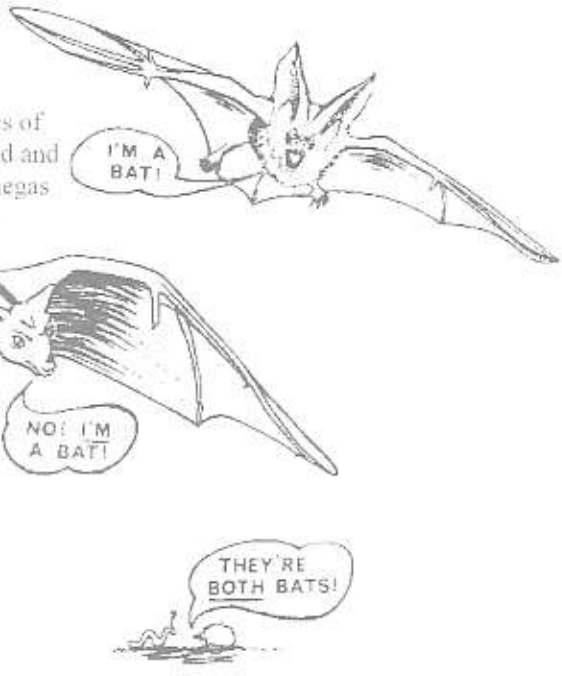
Megas and micros — the great controversy

In the world of bats there are two major divisions; the microchiroptera, which means small hand-wing, and the megachiroptera (large hand-wing).

Although some of the megas are quite small, the differences between the two groups are marked. The megas are vegetarians while the micros (outside the Americas) are insectivores and carnivores. Micros all use sonar (echolocation) while megas depend on vision. Most megas are happy to roost in daylight and do so with their wings wrapped around them while the micros seek out dark places and fold their wings beside their bodies. Megas do not hibernate as many micros do and they have two claws on their forelimbs compared with the micros' one.

While it has long been recognised that micros and megas are very different, the findings of Queensland anatomist and physiologist, Prof. Jack Pettigrew, in the mid 80s provoked uproar in the world of taxonomy and evolutionary science. When working on vision in animals he had been given a flying fox brain to examine. He was amazed to discover that it had a pattern of nerve connections found **only** in primates (monkeys, apes and us). It was totally unlike the brain of a microbat whose visual nerve pattern is similar to that found in all mammals **except** primates. His findings raised the question: did the same optic nerve pattern evolve twice (once in primates and once in megabats) or, as Pettigrew claims, did flight evolve twice in mammals (the two bat groups).

He soon amassed a long list of other anatomical differences (ears, noses, skulls, teeth, tails, wing bones, internal anatomy). Then a statistical technique (cladistic analysis) was used. As many characteristics as possible, from as many species of animal as possible, were sorted and tested for similarity and the megas and micros turned up in quite different categories. The micros ended up, as expected, with the small insectivorous mammals such as shrews (traditionally seen as the evolutionary ancestors of all bats) but the megas kept ending up with primates.



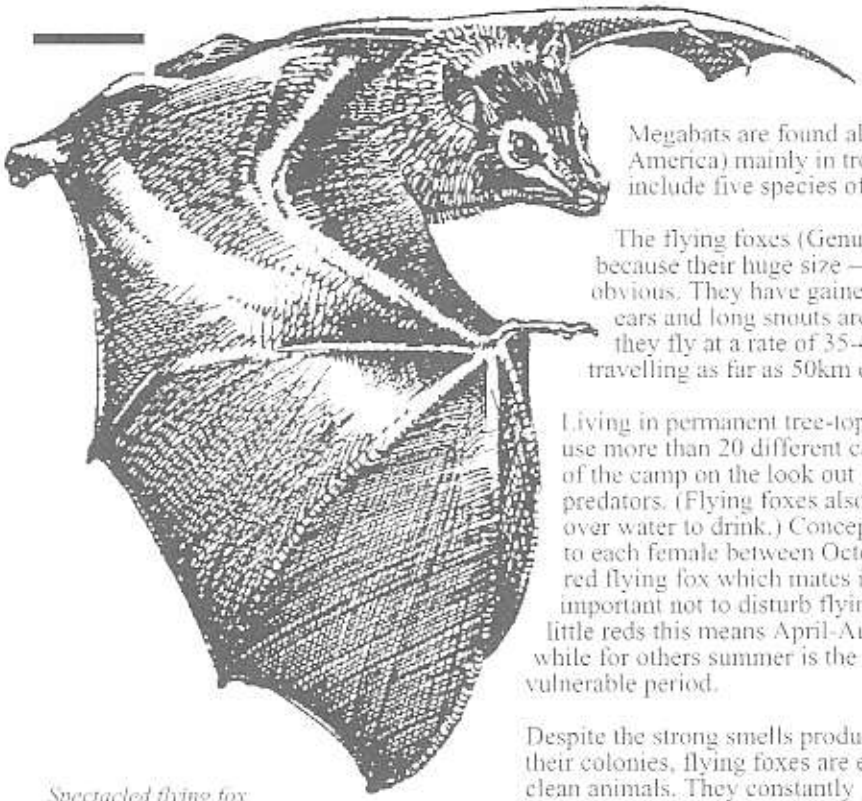
Pettigrew was not actually the first to note the similarity between flying foxes and primates. Linnaeus, the Swedish 'father of taxonomy' had done so in the mid-1770s. Nevertheless, Pettigrew's critics point to the very similar wing structures of all bats, considering it inconceivable that flight might have evolved twice in mammals. The interpretation of DNA analysis (a new technique) may support them but is by no means clear, so controversy rages on. However, the next time you see a flying fox flapping across the sky you can consider it a possible close cousin!

Toothy tales

In 1992 a very exciting tooth was found at Murgon, in S.E. Queensland. It was the tooth of a bat and the exciting thing about it was its age — 55 million years. Not only did it predate the previous oldest bat fossil in the world by five million years but it suggested that placental mammals lived in Australia, alongside the marsupials, about 30 million years before they were supposed to have arrived!

It had always been thought that bats, as one of the first placental mammals to invade Australia, arrived from Asia about 26 million years ago. Certainly many did use this route but how does the Murgon bat fit the picture? Australia was still part of Gondwana 55 million years ago. Did some bats actually evolve in this part of the world? Like all good puzzles the tooth poses many questions.

Megabats



Spectacled flying fox

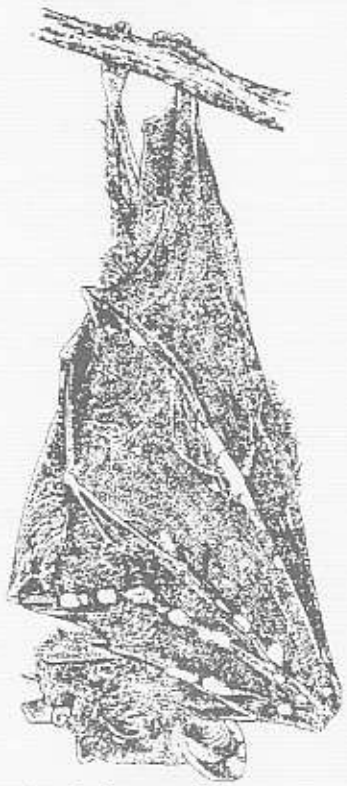
Megabats are found all over the world (outside Europe and North and South America) mainly in tropical areas. There are 11 species in Australia. These include five species of flying fox, plus six of their cousins.

The flying foxes (Genus *Pteropus*) are the best known tropical bats largely because their huge size — wingspans reach up to 1.6m — makes them so obvious. They have gained their popular name because their large eyes, simple ears and long snouts are reminiscent of dogs or foxes. Studies have shown that they fly at a rate of 35-40km/h with an average wing beat of 120 a minute, travelling as far as 50km each night.

Living in permanent tree-top camps, flying foxes have a complex social system and use more than 20 different calls for communication. Old males guard the perimeters of the camp on the look out for eagles and pythons which are their main natural predators. (Flying foxes also occasionally fall victim to crocodiles as they swoop over water to drink.) Conception takes place in March/April and one young is born to each female between October and December. An exception to this rule is the little red flying fox which mates in November/December, giving birth in April/May. It is important not to disturb flying fox camps when the young are being suckled. For little reds this means April-August, while for others summer is the vulnerable period.

Despite the strong smells produced by their colonies, flying foxes are extremely clean animals. They constantly groom their fur and wing membranes while at rest. When they wish to urinate or defacate they turn themselves head up.

Megas ...



Queensland tube-nosed bat
(*Nyctimene robinsoni*)
The 3mm long tubes protruding from this animal's nose make it one of the strangest looking bats. It has been suggested that these tubes allow the bat to smell in 'stereo', thus allowing it to locate food more easily. It is a significant disperser of below-canopy fruits, particularly of figs, its favourite tucker.

This bat has never been seen to roost communally. It is well camouflaged by the white or yellow spots on its wings and ears which cause it to blend in well with sun-dappled foliage. (So good is this disguise one researcher has reported the successful capture of hundreds of dead leaves camouflaged as tube-nosed bats!)

Of ticks, lychees and flying scapegoats

When it comes to flying foxes passions run high. There are those who love them and fear for their future and there are those who call them vermin and want to see them exterminated.

Among the former is a growing group of foster mums and dads who have taken the growing number of flying fox orphans under their wings (so to speak) and found them to be affectionate and intelligent. For many years these came mainly from mothers caught on power lines but recently orphans have been created as huge numbers of spectacled flying foxes on the Atherton Tableland have fallen victim to tick paralysis. This is almost certainly a new phenomenon, not a natural part of the bats' lifecycle. It has been suggested that deforestation is to blame and that the flying foxes, deprived of a food source high in the canopy, are visiting lower food sources, particularly (non-native) tobacco bushes. By coming uncharacteristically close to the ground the bats are coming into contact with the ticks.

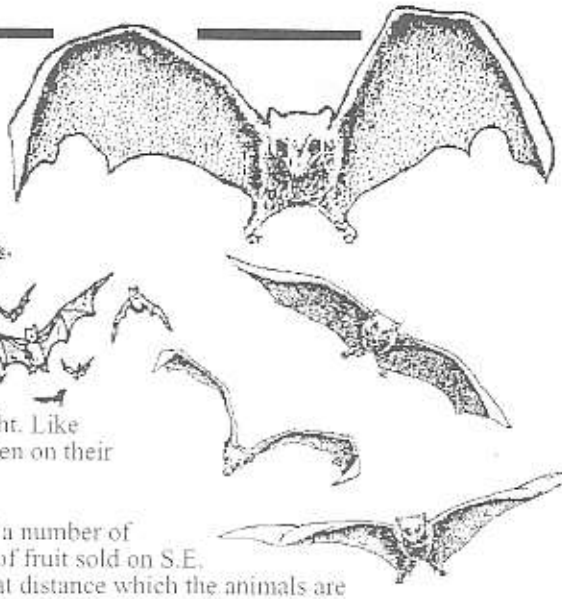
Fruit farmers are often unsympathetic. They see no reason to protect the animals which are raiding their orchards at night. As long ago as the 1930s Mr Francis Ratcliffe was employed to estimate their population numbers and suggest a method of control. He came to the conclusion, after several years of research, that flying foxes are mainly blossom feeders which will choose cultivated fruit only as second best to native fruit. It is likely that bat raids on commercial fruits may be a warning sign that all is not well with the forest. Ratcliffe also pointed out that much commercial fruit is picked by growers before it is ripe — before it can be eaten by the flying foxes. More damage may be done by birds than by bats.

These findings still apply today. Indeed recent research indicates that some fruit farmers have every reason to be grateful to flying foxes. Many fruit species such as bananas have been dependent on bats for pollination and seed dispersal during their evolution. Although genetic engineering can produce many desirable characteristics, when plant breeders want to combat a problem such as fungus attack they need to go back to wild stock for fresh genetic attributes. Without flying foxes and their relatives it would not be there.

The best solution for fruit growers seems to be total exclusion netting which has the added advantage of keeping out birds and protecting crops from hail. A mesh size under 44mm² is recommended to exclude bats as well as birds. Perhaps different solutions can apply to different fruits. Cashew growers have found that flying foxes will carry the fruit to certain perches and drop the valuable seeds. A grove of native trees in the middle of a plantation could allow the growers to harvest the cashews, neatly cleaned of their fruits, from a central spot in their orchard! Perhaps the best long-term answer is to give the bats back their natural, preferred food in the form of native trees. Advice on suitable plant species as well as netting can be obtained from the **Cape Tribulation Tropical Research Station,** PMB 5, Cape Tribulation, Qld 4873; Ph/Fax: (07) 4098 0063; email: Hugh@austrop.org.au

Flying foresters

As night falls millions of flying foxes leave their treetop camps and stream across the sky. At the same time pale blossoms open in the canopy and eucalypt trees increase the supply of nectar to their flowers. These events are linked; the bats and the trees need each other.



The favourite food of flying foxes is pollen and nectar so nectar is the inducement offered by many forest trees for pollination services. In these cases the flowers are usually white or pale, making them more obvious for the bats at night. Like huge honey bees the bats land and, while feeding on the flowers, collect a load of pollen on their fur to be transferred to the next blossom.

It is now considered that bats, rather than insects or birds, are the prime pollinators of a number of important timber as well as many fruit species. (It has been estimated that 70 percent of fruit sold on S.E. Asian markets is bat-pollinated.) An additional advantage of bat pollination is the great distance which the animals are able to fly (50km in one night) allowing cross-fertilisation between distant trees. This is particularly important for isolated rainforest patches which otherwise would have no way to 'interbreed'.

Flying foxes also distribute seeds. Forest trees with pale fruits attract bats and often while they are feeding they swallow small seeds such as those of figs. Unlike birds which tend to sit in trees before depositing the seeds which they have ingested, bats can do so in flight and for this reason are considered vital for the regeneration of forest in areas which have been cleared (and thus have no bird perches). A study in Africa found that up to 95 percent of aerial seed dispersal was due to bats. This service is not limited to small seeds. In order to protect their find from other hungry bats flying foxes often carry away large fruits such as mangoes, dropping the seeds some distance from the parent tree.

Megabats are now being referred to as 'linchpin' or 'keystone' species by research scientists. The linchpin keeps the wheel on the axle and the keystone locks the stones of an arch; without them neither would hold together. Similarly, without flying foxes to pollinate and distribute species on which so many other animals, including the cassowary, depend, our rainforest systems could 'The loss could trigger a cascade of linked extinctions'. 'Loss', in this case, may mean critical reduction in numbers. A colony of 25 000 in a camp covering 1-3ha may seem like a huge number but camps are few and far between (one per 20-50km) so the average may be less than one bat per 10ha. It is possible that many more bats are needed to service the ecosystem. Present bat numbers are only a fraction of previous populations; even now we could be reaching critically low numbers.

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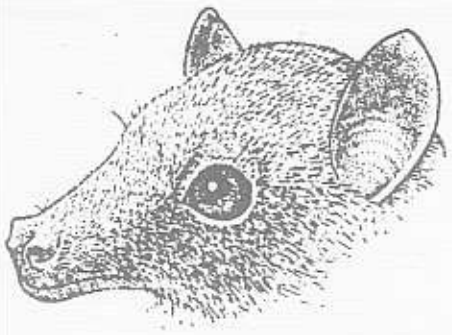


Common blossom bat
(*Syconycteris australis*)
Northern blossom bat
(*Macroglossus lagochilus*)
The main differences between these two species are to be found in their teeth and their distribution.

Although it is a mega, each blossom bat, at about 15g, is smaller than a mouse. Its pointed nose and long thin tongue are highly specialised for penetrating flowers and licking up the nectar. Any of the trees with 'shaving-brush' flowers are likely to be visited by this bat. A CSIRO study proved its significance as a pollinator of the bumpy satinash tree (*Syzigium corniflorum*). Various cages were placed over blossoms to allow selected access to flowers by insects, honeyeaters and blossom bats. Results showed that blossom bats performed 46 percent of the pollination while birds and insects were responsible for only 20 percent each.

... Wet Tropics

Spectacled flying fox
(*Pteropus conspicillatus*)
A specifically rainforest species, this is the main flying fox inhabitant of the Cairns central swamp.

Little red flying fox
(*Pteropus scapulatus*)
Our most widely-distributed flying fox, it is not found outside Australia. Huge numbers of this wandering bat move to coastal areas in years of inland drought and poor eucalypt flowering.

Black flying-fox
(*Pteropus alecto*)
Camps of up to hundreds of thousands of bats are often situated in mangrove and paperbark swamps.

Bare-backed fruit bat
(*Dobsonia moluccensis*)
Restricted, in Australia, to northern Cape York including the Black Mountains, near Cooktown, this is the only Australian mega to roost in the semi-darkness of caves. It is also the only fruit bat which can fly backwards!

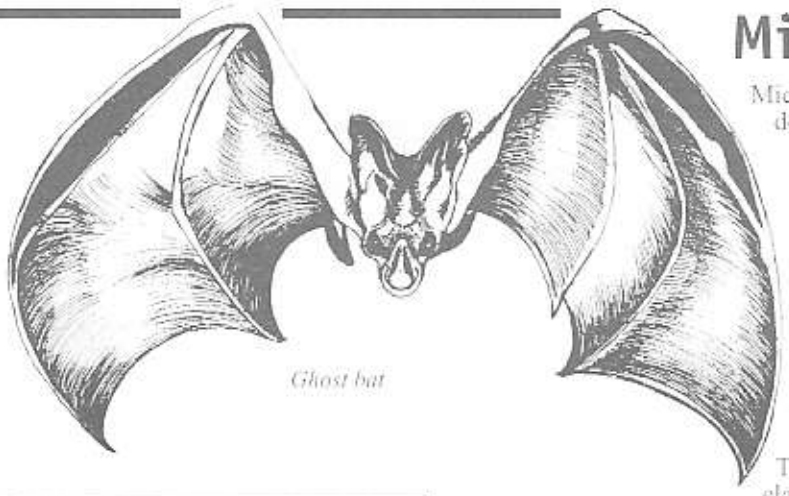
Wanted, dead or alive

All Tableland flying foxes reared and released into the wild have had metal thumb bands attached. If you find one of these (dead or alive) please contact the address of the Australian bird and bat banding scheme printed on the band or the **Cape Tribulation Tropical Research Station.** Ph/Fax: (07) 4098 0063. Each reported find represents a great deal of useful information.

Bats as tucker

Bats, particularly flying foxes, are a source of food in many parts of the world. They are also believed to have medicinal properties effective against anything from snake bite and asthma to fractures. Sadly the human appetite for bats is seriously endangering many species and with locals in Guam paying up to $25 a kilo for them a brisk export business has sprung up in other areas. This has led to the extinction of some island species.

Microbats



Ghost bat

Microbats are found all over the world except in the driest desert areas and the poles. Interestingly, although they are exclusively insect and meat eaters elsewhere, in the Americas, where there are no megabats, many microbats eat nectar, pollen and fruit.

Most microbats are social. Almost all avoid daylight by roosting in crevices, caves, treehollows, folded leaves, under bark or in roofs. Unfortunately many of these sites are being destroyed by human activity. This is particularly important when it affects maternity sites, where temperature, humidity and freedom from disturbance and predators are critical.

The newborn young at first hangs on to its mother using its claws and teeth (attached to her nipple) as she flies around. Later the hairless youngsters remain in the maternity site huddled together with one mature female left behind as the 'babysitter'. Mothers are able to locate their own particular babies among thousands, probably using their sense of smell. It seems that females of many species spend little time with the males, forming instead their own close-knit groups and residing in stable colonies, while the males tend to rove around.

Fears and cures

Traditionally bats have been symbols of evil, presumably because of association with night and darkness. On the other hand, they are symbols of health and prosperity for the Chinese (and luck for gamblers) and they have long been associated with medicine.

Bats have become the subject of modern research. For example, study of sonar has proved useful for producing a walking stick with echolocation for blind people and for developing non-destructive testing using ultrasound.

Combatants

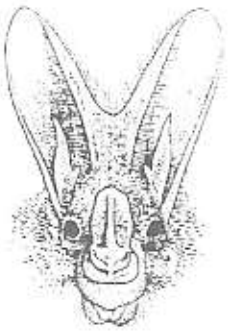
Bat droppings are a rich source of nitrates which were once used to produce gunpowder. Tonnes of bat guano were mined from Johannsons Cave near Rockhampton during the First World War. Odder still was an American plan, during the Second World War, to attach small bombs to freetail bats. The idea was to drop numbers of these mini-bombers from planes on to enemy territory. They would then find their way into buildings where the bombs would detonate. The plan backfired, however, when armed escapee bats roosted in the army's own buildings and blew them up! When several hundred mini-bombers roosted under an elevated petrol tank in a nearby town the project was abandoned and the Americans moved on to the development of the atomic bomb.

Micros in the Wet Tropics

The Wet Tropics is home to representatives of all six groups of Australian bats — evening, freetail, Megadermatidae (big-skin), sheathtail bats and two groups of horseshoe bats. A few of the 40 or so Wet Tropics species are featured here.

Ghost bat

(Macroderma gigas)

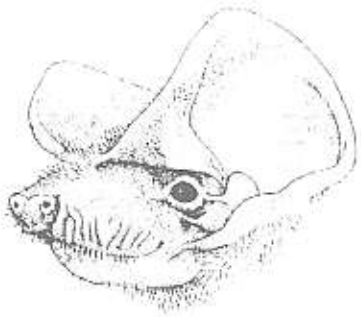


Australia's only carnivorous bat, the ghost bat, eats frogs, lizards, birds, small mammals (including other bats) as well as large insects. It has good vision and huge ears which are used to listen for noises made by prey, as its sonar is quite weak. It then swoops down on its prey, enveloping it with its wings and killing it with powerful bites.

The ghost bat, at 150g (about the size of a magpie lark) is one of the largest microbats in the world. Its distribution is patchy over northern Australia and it is particularly at risk due to limestone mining threatening its habitat.

Northern freetail bat

(Chaerophon jobensis)



Every year in Cairns and Kuranda there is a rash of enquiries about 'baby flying foxes' found in people's houses. These usually turn out to be freetail bats, one of the commonest of the microbats found in urban areas where they have found house roofs much to their liking. They tolerate the high temperatures that exist in roof spaces but it is possible that finds coincide with the onset of hot weather when roofs become too hot, forcing the bats to leave. They are small (20-30g) with big ears, faces like cocker spaniels, very short hair and long tails. (They are also called mastiff bats.)

Tube-nosed insect bat

(Murina florium)

This bat was caught for the first time in Australia (16th time in the world) on the Atherton Tableland in 1981. Although thought to be confined to misty mountainous areas two were later caught on coastal lowlands north of the Bloomfield River. It is not now considered as rare as originally supposed.

Large-footed mouse-eared bat

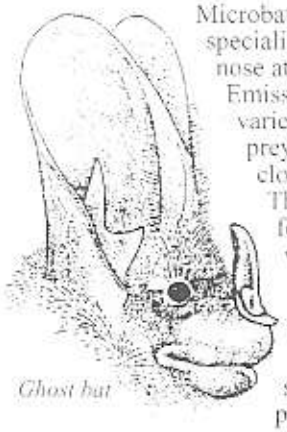
(Myotis moluccarium)*

This is Australia's equivalent of the Central American fishing bats. The large-footed myotis frequents still bodies of water where it flies across the surface raking the water with the claws on its large feet to catch aquatic insects. These bats often roost under bridges above rivers where breeding males defend harems of females.

*Formerly *M. adversus*

Hearing the way

No bats are blind, although many have small eyes. Microbats depend largely on sonar, or echolocation. Sonar is distance-measuring with sound (not to be confused with radar, which is distance-measuring with radio waves). Some other animals, such as whales, dolphins and shrews also use sonar.

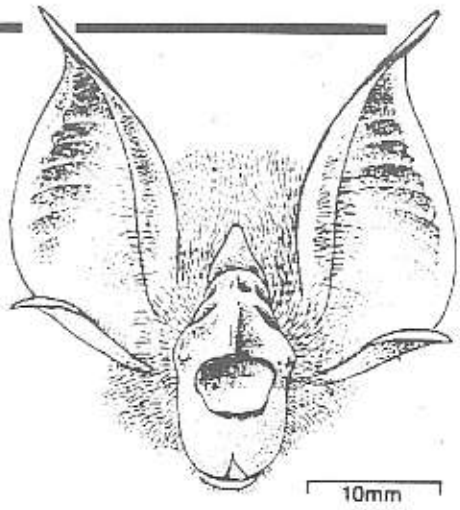


Ghost bat

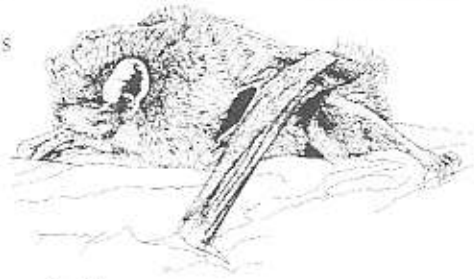
Microbat sonar, at frequencies of 15-200KHz, is produced by a very specialised larynx (voice box) and beamed out through the mouth or the nose at rates up to 200 pulses a second. Sonar is a complex process. Emissions may vary in intensity, frequency and pulse rate and can be varied depending on whether a bat is 'searching' or 'homing in on' prey. If the bat is a nose-sonar specialist, it flies with its mouth closed and has folds of skin around its nose to 'beam' the sound. These are usually called nose-leafs and can be quite bizarre in form. The mouth-sonar bats (such as our little freetail bats) fly with their mouth open and usually lack facial decorations.

Since microbats rely on hearing the reflection of sound waves, they often have big ears with all sorts of wonderful convoluted trumpet and horn-like shapes, to catch and focus the fainter sonar echoes. Those with small ears have a mouth sonar which is probably particularly loud.

A large part of a bat's mid-brain is used to interpret the sonar input to the ears. It is thought that the signals are processed to construct the equivalent of our visual picture of the world. It is certainly very accurate. Scientists have been able to train a microbat to distinguish between fine-grade and medium-grade sand-paper to find food! The rare golden-tipped bat (*Kerivoula papuensis*) can detect spiders' webs. It probably hovers and picks its prey from the web — some have been found with stomachs full of orb-weaving spiders. It has the quietest sonar of all Australian bats and probably flies very slowly. It quite easily detects and avoids mist nets used to trap other microbats.



Large-eared horseshoe bat

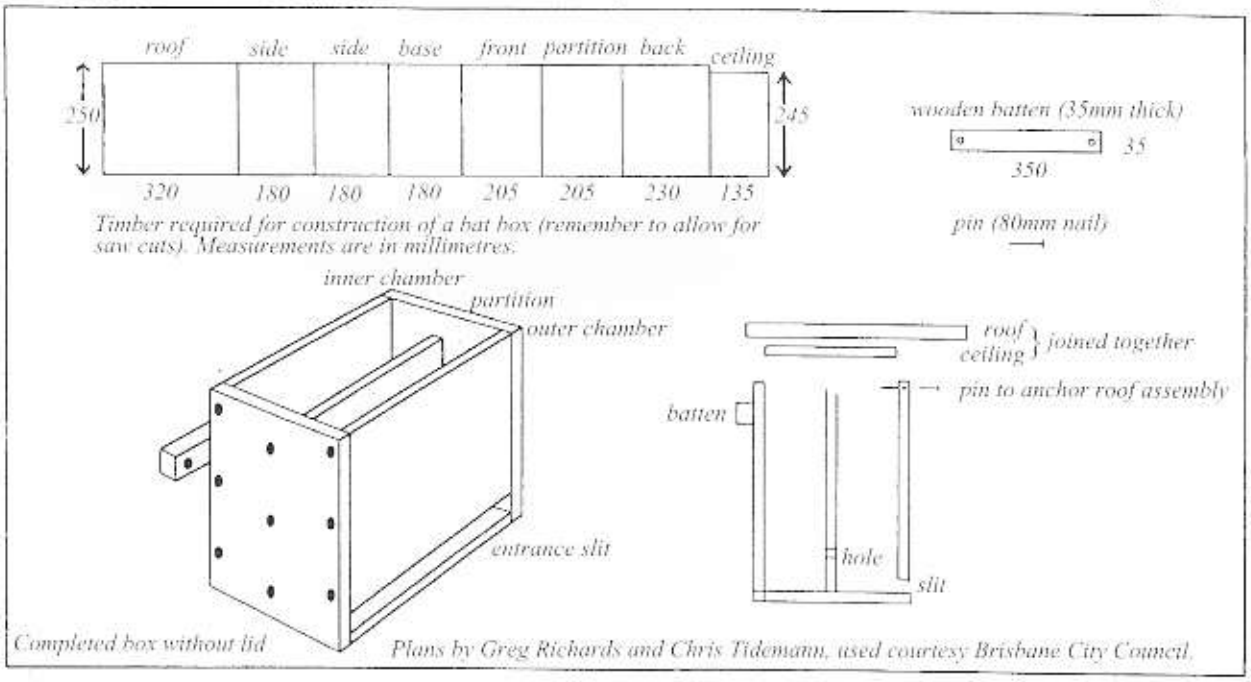


Little bent-winged bat

Batty pesticides

Little microbats are able to eat between a third and a half of their own body weight in insects each night — that is up to an estimated 3 500 for one pipistrelle! A colony of 100 000 individuals may eat between 200 and 400 tonnes of insects in a year!

Encouraging bats into our backyards could help reduce the number of mosquitoes — and the diseases they spread. If you want to do this you could try making and installing a bat box. We are therefore reproducing a design for one here.



Timber required for construction of a bat box (remember to allow for saw cuts). Measurements are in millimetres.

Completed box without lid

Plans by Greg Richards and Chris Tidemann, used courtesy Brisbane City Council.

It should be mentioned that this design is based on a European one and will not necessarily appeal to Aussie bats. In fact, different species may need different types of boxes. For example, a cardboard carpet tube capped at the top, waterproofed and lined with carpet with a side hole near the bottom might be a hit with some bats. However, as long as you realise that success is not guaranteed, there is no harm in trying this design. Perhaps you could experiment — the research needs to be done! In the meantime, remember that the roofs of our houses are among the best bat boxes and that the removal of trees with hollows may destroy some homes — and our natural pesticides.

Bat box hints

- Untreated, unpainted timber is best.
- Keep it simple. An old hollow log mounted upside down with a small entry at the bottom will be just as attractive to many bats.
- Place the box at least four metres above the ground — in the bats' flight path.
- The box will be easiest for a bat to find if it is facing the north-eastern aspect and is in a tree without dense foliage.
- If you have a lot of trees, the box is best placed in one on the edge of the group — again, it's easier to find.
- Gum trees and paperbarks are ideal.
- Don't secure the box with a permanent wire or band around the trunk as it could harm the tree's growth.
- Make the entry to your box small — if the hole is too big, other animals such as birds will move in and discourage bats.

Facts and stats

on bats

There are between 800 and 1000 species of bats in the world (depending on the taxonomy used.) Australia has over 70 species, representing six out of 16 families. About half of them are endemic (found only in Australia). They represent about 30 percent of our land mammal species, the second most numerous group after marsupials (45 percent approx.). Over 60 percent are found in the Wet Tropics.

Bats are the only mammals which can fly (some others can glide) and are the third group of vertebrate animals to have taken to the air, after the prehistoric pterosaurs and birds.

By hanging upside down bats are able to reduce the size of muscles in their hips and legs. Tiny legs reduce flight loadings — an evolutionary trade-off for flight.

Some microbats drink by wetting their fur as they fly over water, licking up the moisture later.

Hibernating microbats in high altitudes and latitudes allow their body temperature to fall within a few degrees of air temperature. If the external temperature falls below zero the bat's thermostat switches on an internal heater. Once the temperature reaches about 15deg., which is the point at which the majority of insects start to fly, some mechanism wakes the bats for a feed. Many hibernating bats mate before winter but the females store the sperm through the winter and become pregnant as soon as they wake up in the spring.

Two rare bats are New Zealand's only native land mammals. One of them lives in burrows and eats fungus!

The smallest bat (and mammal) in the world weighs 1.5g. The bumble-bee bat from Thailand is highly endangered because locals catch and mount them for sale to tourists! One found its way, in a perspex paperweight, to the British Museum where it was discovered to be not only a new species but an entirely new family! Our smallest bat is the Timor pipistrelle which, at 3-5g, weighs the same as an empty matchbox.

A 54g Queensland tube-nosed bat has been caught carrying a 30g fig fruit 50m from the nearest fig tree — indicating the potential of these bats as dispersers.

Bookshelf

Complete Book of Australian Mammals
Ronald Strahan (ed)
Angus and Robertson Publishers (1995)

Over 130 pages of this excellent book deal with all the bats known (in 1995) to exist in Australia. Each species is described and illustrated with photo(s) and there is a good general introduction.

Bats A Natural History
J.E. Hill and J. D. Smith
British Museum (Natural History)
(1984)

A comprehensive and fascinating look at bats: structure, origins, flight, food, thermoregulation, reproduction, echolocation, population, man and bats and families.

Australian Natural History Vol. 24 No. 4 Autumn 1993
The Contentious Flying Fox
Chris Tidemann

This article looks at the ecological importance of flying foxes.

Wildlife Australia Vol. 21 Issue 4 Summer 1984
Like Bats into Hell
Catherine Creevey

A protest after flying foxes were removed from Queensland's protected fauna list.

Australian Natural History Vol.24 No.12 Autumn 1995
The bat with the stereo nose
Les Hall and Jack Pettigrew

Some interesting findings (and more questions) on the Queensland tube-nosed bat.

Geo Vol. 10 No. 3 1988
Echoes in the Dark
Dr W.R. Phillips

This informative article deals largely with microbats although megas are mentioned. The focus is on north Queensland bats.

Australian Natural History Vol 22 No 10 (p450) Spring 1988
Maybe Bats Ain't Bats
Dan Walton

Ecos No 43 1985 (back cover)
Learning from Bat's Ultrasound
Andrew Bell

A short article dealing with sonar.

Australian Mammalogy 13: 17-31
The Spectacled Flying Fox in North Queensland: Roost sites, distribution patterns, diet, seed dispersal and feeding ecology
G.C. Richards

An academic study of our local bat.

Video:
The Flying Foresters
BBC video narrated by David Attenbourgh

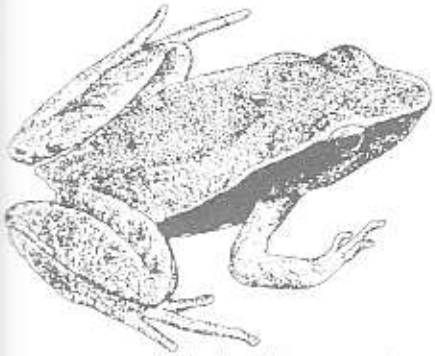
Tourist talk

ENGLISH	GERMAN	JAPANESE	
bat	Fledermaus	komori	こうもり
flying fox	Fledermaus die sich von Früchten ernährt	ookomori	おおこうもり
primate	Primat	reichorui	霊長類
nectar	Nektar	hana no mitsu	花の蜜
pollen	Pollen	kafun	花粉
fruit	Frucht	kajitsu	果実
insects	Insekten	konchu	昆虫
sonar	Echolot	onpa hankyo	音波反響
tick	Zecke	da ni	だに
roost	sitzplatz	negura ni tsuku	ねぐらにつく

Frogs

Frogs croak

In 1991 the streams on the Mount Carbine Tablelands were quiet. In previous seasons they had resounded to the calls of frogs but in the space of one year, researchers discovered, five species of frogs had apparently disappeared. For example, the sharp-snouted torrent frog (*Taudactylus acutirostris*) previously found at densities of up to 100 in 100m of stream, had completely vanished. It is now known that between 1989 and 1994 six stream-dwelling frog species disappeared from the Wet Tropics uplands. What happened? Where did they go?



The last sharp-snouted torrent frog (Taudactylus acutirostris) *was seen in 1994.*

Those questions are being asked worldwide. In many countries the reasons are obvious — pollution (especially acid rain), insecticides, herbicides (frogs are especially vulnerable because they absorb moisture through their skin), land clearance and channelisation of rivers not to mention the catching of large numbers of frogs for the dinner table. But what about amphibians vanishing from apparently pristine environments — the high mountain lakes in North America, the forests of Costa Rica and the tablelands of the Wet Tropics?

The Australian wave of disappearances was first detected in southern Queensland 13 years ago and has been working its way north. It devastated frogs of the Atherton Tablelands a year before moving on to the Carbine Tablelands. Generally those frogs which breed in upland rainforest streams — ideal frog habitats — have been affected. Interestingly, some species which also occur in lowland areas have vanished only in their upland habitats.

Is the frogs' disappearance an early warning of environmental degradation? It has been suggested that they may be victims of ozone depletion over Australia, although it seems unlikely that nocturnal forest dwellers would be the first to suffer. Is a disease responsible? Perhaps the disappearances are a natural part of frogs' life cycles and they will just as suddenly reappear — although rainforest creatures don't normally go through boom-bust cycles common in other less 'stable' habitats.

We need to know. Researchers from Department of Environment, James Cook University, and Cooperative Research Centre for Tropical Rainforest Ecology and Management are trying to come up with answers. Hopefully they can shed light on this disturbing mystery.

The missing six

Three frog species have completely disappeared:
Sharp-snouted torrent (day) frog
(Taudactylus acutirostris)
Northern tinker frog
(Taudactylus rheophilus)
Mountain mist frog
(Litoria nyakalensis)
Three species have disappeared above 450m:
Waterfall frog *(Litoria nannotis)*
Common mist frog
(Litoria rheocola)
Australian lace-lid
(Nyctimystes dayi)

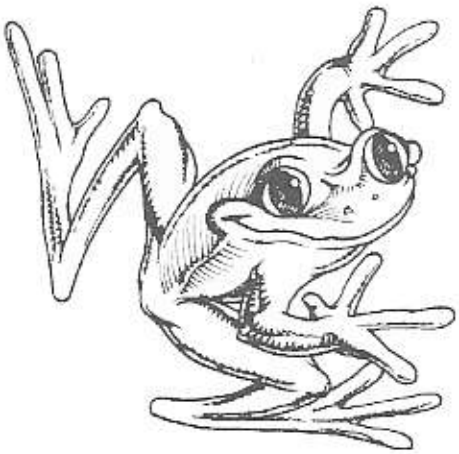
Frogs in the Wet Tropics

The Wet Tropics is a very special area for frogs. Representatives of all five Australian frog families are found in the area (including the introduced cane toad as the only, but numerous, example of the *Bufonidae* family). Many are endemic to the region — more than 20 species are found in the rainforests of the Wet Tropics and nowhere else. Of those, many are limited to very small areas. The Thornton Peak tree frog (*Litoria lorica*) apparently occurs only above 640m on Thornton Peak.

Our knowledge of rainforest frogs is very recent. About half of them have been studied and given scientific names since 1970 and more are being found. However, faster than they are being discovered, the frogs seem to be disappearing.

Frogs are important. In areas of the world where frog numbers have been seriously depleted, people have discovered, too late, the value of their free insect-control service. Rainforest frogs are an important part of the ecosystem. Tadpoles, in particular, feed on leaves and convert them into protein (themselves) forming a vital link in the food chain. Frogs are eaten by a wide range of other animals.

Frogs have been around much longer than us. They were tough enough to survive the dinosaurs so what is happening to them now?

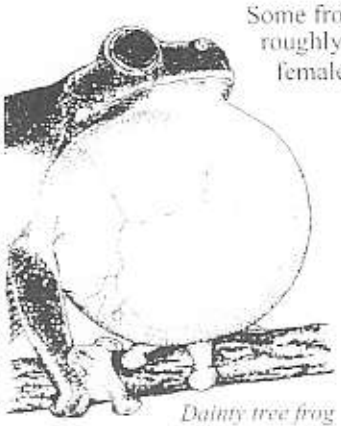


Froggy facts

Loudmouths

Only male frogs can call. They have an inflatable vocal sac below their lower jaw. This does not make the sound, but acts as a resonance chamber to increase the volume of the frog's call. Some sacs inflate externally but others inflate internally making the whole frog blow up.

Some frogs have two-part calls which, roughly translated, mean, 'Come here female' and 'Get lost other males'.



Dainty tree frog

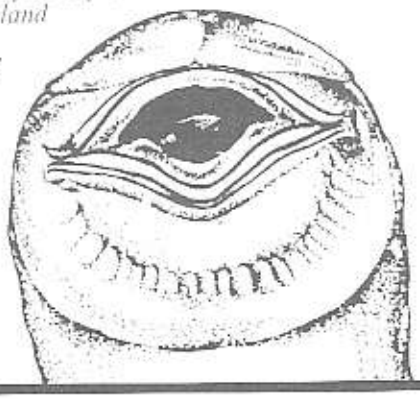
Foam beds

About 25 of Australia's frog species (the dainty tree frog, *Litoria gracilenta*, is a Wet Tropics example) make foam rafts for their eggs. While mating, the female paddles with her front feet and pushes air bubbles under her body where they mix with spawn. This raft keeps the eggs at the surface of the water where it is warmest. Higher temperatures lead to faster development so the raft may enable those eggs to hatch and the tadpoles to get to the food faster than other species which spawn at the same time.

Sweetlips

Some tadpoles which live in fast-flowing water have suckers around their mouths to help them hang on to rocks. Within the suckers there are two parts to the mouth. Thin black lines (there can be up to 15) are rows of fine teeth which scrape algae off rocks. Inside these is a thick black horny beak which can chop up large items.

This tadpole, of Nyctimytes dayi, *lives in upland and lowland rainforest streams between Cooktown and Townsville*

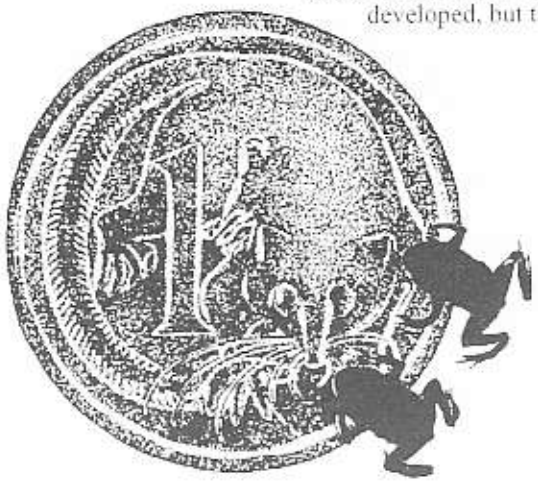


Australia's mini-frog

Cophixalus hosmeri is the smallest frog in Australia. The adult male frog is a mere 11-14mm in length — half the length of a standard paperclip — and the newly hatched froglets are even tinier. It lives in a small area, in the cool wet rainforests of the Carbine Tablelands above 940m.

Little *C. hosmeri* is commonly known as the fast-rattling frog because of the short, fast, rattling call of the males heard on moist summer nights. There is also a slow-rattling frog. As no two frog species' calls are alike scientists who use the calls to locate and identify them sometimes name the frogs after their calls.

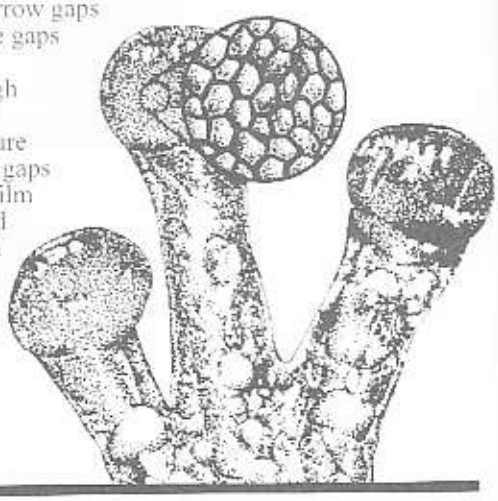
These frogs, like others in the same microhylid group, don't spawn in water and there are no free-swimming tadpoles! The female lays her eggs in a shallow burrow beneath logs or fallen epiphyte clumps. She produces only seven to 11 eggs (compared with up to 30 000 for the cane toad) but they are relatively big because each has a large yolk to supply the developing frog with plenty of food. The parents stay close to the eggs and may even spread an anti-bacterial and anti-fungal substance on them. The embryo does become a tadpole — but safely inside the egg. It doesn't hatch until it is a fully-developed, but tiny frog.



These tiny, newly-hatched froglets, beside a one cent coin, belong to the same Microhylid family as the fast-rattling frogs. They could well be the smallest fully-formed frogs in the world.

Sticky toes

Why do tree frogs not fall off? Climbing frogs have large flat discs on the tips of their toes and fingers. A close look, with electron microscopes, shows that the skin on the bottom of these pads consists of a pattern of interlocking irregularly-shaped cells with narrow gaps between them. These gaps can catch on tiny irregularities on rough surfaces. On smooth surfaces extra moisture drains away into the gaps leaving a thin even film which allows the pad to stick. Similar skin on the lower side of many frogs enables them to hang on with their stomachs too.



Building a frog pond

A good way to help frogs is to build a breeding pond in your garden. Anything, from a garden pond to a broccoli box, is suitable as long as it is shaded and the froglets can eventually climb out.

Your pond should be filled with rainwater or pondwater and, if possible, be above ground level to prevent cane toads from breeding in it. Otherwise, surround it with a 50cm high bird-wire fence with 1cm holes. Put the fence as far away from the pond as practical.

Cane toads are a risk to tadpoles and mature frogs. Whether or not you have a pond, it is a good idea to collect them at night and freeze them in a plastic bag. Beware the poison glands on their backs. Another humane method for killing them (there is no reason to be cruel — they didn't ask to come here) is to squirt them with Dettol or Toadex — but *not* salt. The bodies can be composted.

Toad eggs should be removed from your pond, or they will poison your water and the 'toadpoles' will eat your tadpoles. It is easy to distinguish frogs' eggs and tadpoles from those of toads. Toad eggs are the only ones laid in long clear strands, the eggs appearing as a row of little black dots. They can be destroyed by being taken out of the water and left to dry.

Toad tadpoles are the only pure black ones in Australia — native frog tadpoles have light-coloured undersides. Surprisingly, toad tadpoles tend to be smaller and are usually found in dense swarms.

Mosquito larvae can be controlled by introducing suitable fish. Be careful, however, as some species also eat tadpoles and young frogs. Suitable native fish for the job are McCulloch's rainbowfish, splendid rainbowfish, Pacific blue eye, fly speckled hardyhead and fire-tail gudgeon. Exotic white cloud mountain minnows can be bought at pet shops.

Given the correct environment, the tadpoles more or less look after themselves, although they do like a feed of boiled lettuce and fish food.

For more information find details in an excellent and inexpensive booklet, 'Raising Native Frogs' by Alastair Bax, in the Bookshelf section at the end of this chapter.

Readers might be interested in joining the **Tablelands Frog Club**. More information from The Secretary, Tablelands Frog Club, Mail Bag 71, Yungaburra, Qld 4872.

Weedkillers can be frog killers

Children in a Cairns pre-school were upset one morning to find 'their' green tree frogs dead. Gardeners had recently been spraying with a glyphosate weedkiller and this was thought to have caused the casualties. Frog skin is permeable. It allows water and oxygen as well as less benign substances to penetrate.

Weedkillers containing glyphosate are used widely in agriculture, industrial situations and in home gardens. They break down quickly after application and are considered relatively environmentally friendly. However, the surfactant, or wetting agent, used in them (not the actual glyphosate itself) can be fatal to frogs and tadpoles.

Please avoid using these products in or near aquatic environments or in other areas frequented by frogs. Cool, dry weather is the safest (and most effective) time to use them but be careful — a warm damp night in winter may entice frogs to leave their hiding spots and make contact with the sprayed vegetation.

It is possible to produce glyphosate weedkillers without the toxic surfactants. These are now being manufactured so, when buying a herbicide, ask for them if intending to use them in areas frequented by frogs.

Frog spotting

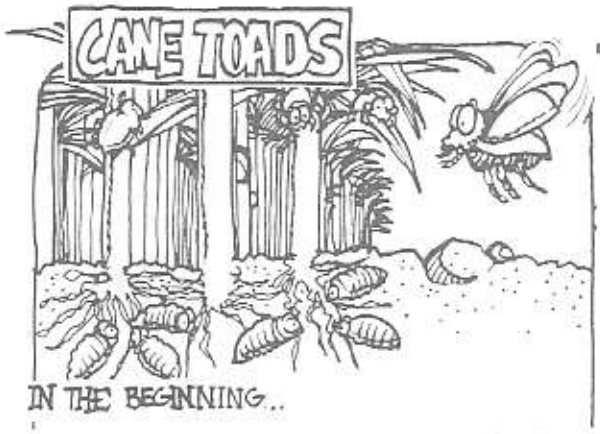
Frog fauna in rainforests on a warm, wet night can be the subject of a fascinating spotlighting walk. As frogs' eyes are not particularly reflective, the best way to find them is by careful searching in undergrowth along tracks (especially on lawyer cane leaves) and along streams and by listening for calls.

With the onset of the wet season rains, the frog chorus provides an excellent opportunity to track down the callers. However, you don't have to wait until then to see frogs on a night walk as some can be found in cooler months, especially on the lowlands. Some of the larger species of tree frogs, such as the giant green tree frog (*Litoria infrafrenata*) with its prominant white lower lip, and the green-eyed tree frog (*Litoria genimaculata*) with its fringed back legs, are still active at night along creeks, tracks and roadsides. During the day, frogs can also be found under rocks and logs, where they will remain until the weather warms up. (Don't forget to replace their shelter after you've looked at them).

One of the most common frogs found between Mt Spec and the Carbine Tablelands, the ornate litter frog (*Cophixalus ornatus*), has a call like a 'squeaky wheel bearing'. Calling frogs can be found anywhere from the leaf litter on the forest floor to perches 2m above the ground, on tree trunks or leaf blades. While they are commonly found in the same spot every night, finding them can be difficult as they seem to throw their voices. The easiest way to locate this frog is to triangulate its position using two people with torches standing a few metres apart. When the frog calls, both people should shine their torches at the position from which they think the frog is calling. A thorough search of the area where the torch beams intersect will usually find the animal — a small, pale blotched frog less than 3cm long.

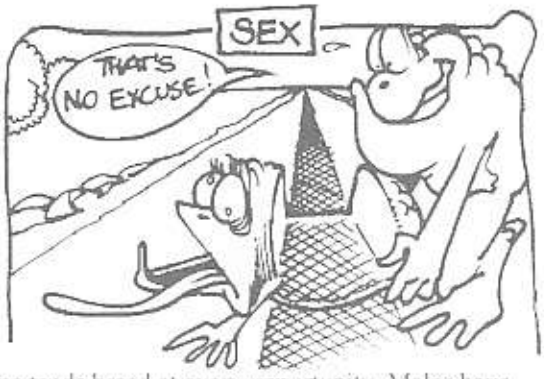
Northern barred frog

Another frog commonly found calling on warm nights by streams is the northern barred frog (*Mixophyes schevilli*). Again this species is almost impossible to find unless it is calling as it blends well with the leaf litter on the forest floor. With its gutteral 'warrk' call, prominent barred thighs and large size (up to 13cm in length) this frog is easy to identify.



The farmers were desperate. Along the Queensland coast clouds of grey-backed and frenchi beetles were feasting on sugar cane. Native to the area, when their rainforest home was destroyed, they switched to sugar — and there was plenty of it. They dropped their eggs into the soil where the developing larvae feasted on the roots.

Then, in 1932, Australian farmers heard of a South American toad, *Bufo marinus*, eating sugar cane pests in Puerto Rico. In 1935, 102 toads were imported. Within six days they had laid eggs and by March 1937, 62 000 toadlets had been released into the cane fields.



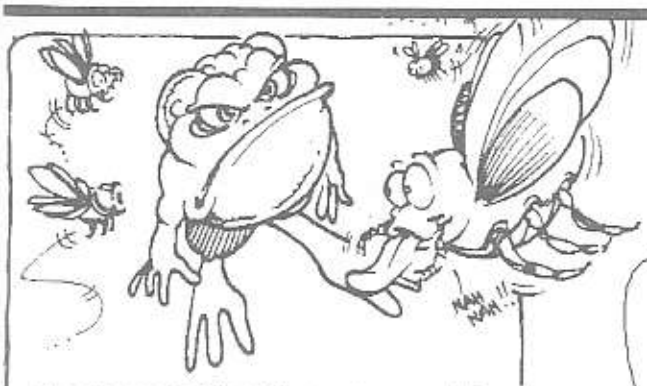
Cane toads breed at every opportunity. Males have attempted to mate with dead (squashed-on-the-road) females, human feet and goldfish. Females lay up to 90 000 eggs a year, in 20m long strands. Eggs hatch in about 48 hours and tadpoles develop into toadlets in about one month. Only one in 200 of the eggs will survive to maturity but individual toads can live up to 16 years.

Toxins are produced from glands on a toad's shoulders which, if squeezed, can shoot the poison up to one metre. If it enters the eyes it causes great pain and temporary blindness. Most of a toad's body is toxic; a Sydney student who ate the ovaries of one for a bet won $20 and a cardiac arrest.

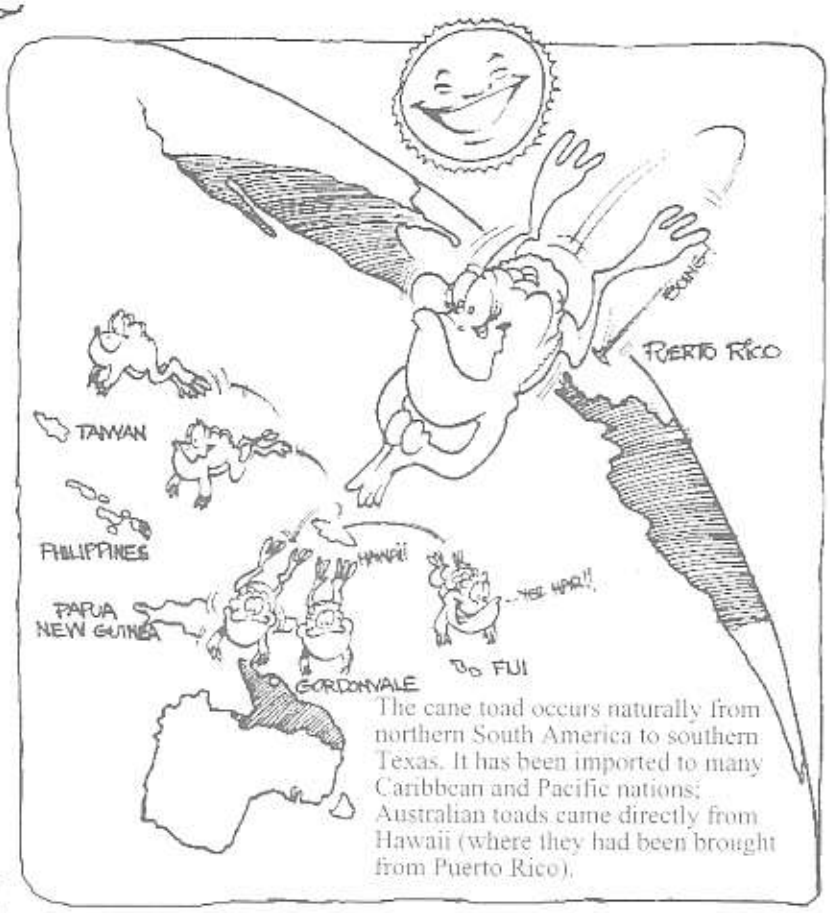
Cane toads have colonised much of Queensland and are marching into the Northern Territory at the rate of 40km a year. Their natural habitat is fairly dry so they move through dry areas more easily than through rainforest. The biggest toads and largest numbers are found on the invasion fronts where they gorge on new food sources. There are actually fewer toads in the areas where they were originally released because populations there have stabilised.

Cane toads are a menace to the environment. They gobble up insects, small snakes and small mammals and also poison animals — birds, snakes, lizards and mammals, including cats and dogs which try to eat them. But the greatest damage may be done by the toad's poisonous tadpoles and eggs which kill aquatic creatures.

When cane toads first arrive in an area, populations of goannas and brown snakes, in particular, are devastated. Then numbers recover. Possibly these animals develop an immunity to the poison or learn not to eat them. Scientists have discovered that goannas from Townsville will refuse to eat toads offered to them while goannas from the Northern Territory, which have not encountered them in the past, will snap them up.



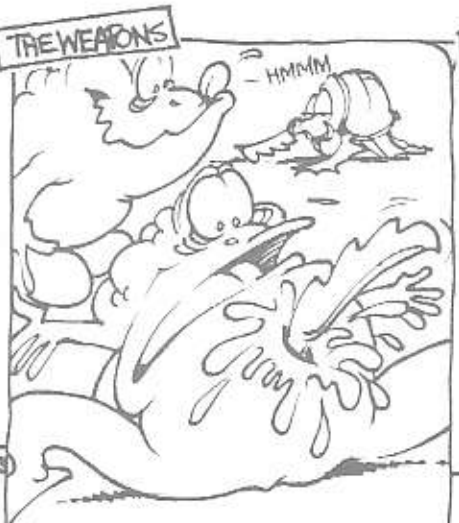
The cane toads did not live up to expectations. Scientists had overlooked one small detail; cane beetles can fly but cane toads can't. Neither were they inclined to try when all they needed to do was sit under a street lamp and scoop up the mouthfuls of insects which fell at their feet. It wasn't until 1947, when the chemical BHC was introduced, that the beetles were finally beaten.



The cane toad occurs naturally from northern South America to southern Texas. It has been imported to many Caribbean and Pacific nations; Australian toads came directly from Hawaii (where they had been brought from Puerto Rico).

Cane toads eat anything small enough to fit into their mouths. Like other frogs they are attracted by moving objects and snap up insects, lighted cigarette butts, table tennis balls, mouthfuls of bees as they land at the entrance to hives and even their own young. They also eat food which doesn't move, such as dog food and kitchen scraps. Some of the largest toads come from chicken farms where they gorge on chicken droppings laced, presumably, with growth hormones.

Some animals have learned to eat toads safely. Water rats, kookaburras and crows turn toads on their backs and eat poison-free parts such as the legs. Ibis seem to be unaffected by the poison and can eat the whole animal. Keelback snakes, freshwater turtles and crayfish can eat large numbers of toadlets.



Researchers have found a potentially deadly virus but fears of its effect on native frogs prevent its use. Another possibility is a very powerful dung beetle which, when swallowed whole, would then burst out of the toad's body. However, scientists will think twice before letting another exotic creature loose in Australia.

Prince Charles and Princess Diana were officially delighted to receive a book bound in cane toad leather as a wedding present. The Japanese use the poison as an aphrodisiac and hair restorer, the Chinese are said to use it in heart operations and it could become a dental anaesthetic.

Facts and stats

on frogs

Frogs appeared on Earth about 200 million years ago. (We arrived about two million years ago.) There are over 4000 species in the world and over 200 species in Australia.

The tadpole of the northern barred frog (*Mixophyes schevilli*) is the largest in Australia growing up to 16cm long (longer than a standard ball-point pen). Adults are 8-13cm long and are widely distributed throughout the Wet Tropics. These tadpoles are particularly important in the forest because they eat, and recycle, very large quantities of leaves.

The frog with the longest leap in Australia lives in the Wet Tropics. The wood frog (*Rana daemeli*), a frog of 75mm, can cover a distance of about 2.5m in a single bound.

The time taken for tadpoles to change into mature frogs varies from one week, for those in arid zones which have to take advantage of water quickly when it is available, to over one year for some in rainforest streams.

All eggs laid in open ponds have a black patch at the top. This is a filter which cuts out the harmful ultraviolet rays in sunlight which would harm the developing frogs.

Frogs' eyes bulge out giving them all round vision. They also may help the frog swallow. When the frog has caught a mouthful of food the eyes sink through an opening in the skull and probably force food down its throat.

Many frogs produce chemicals on their skin which seem to protect them from bacteria and fungi. Frogs have been used in traditional folk medicine all round the world and now modern scientists are using them to develop medicines. A chemical compound which comes from the skin of green tree frogs is used as a gut stimulant after abdominal surgery and also to block schizophrenia symptoms. One Ecuadorian frog produces a painkiller 200 times more powerful than morphine while other frog compounds contract and dilate blood vessels, make hearts beat more strongly, aid food absorption, combat viruses and may eventually be used to repel mosquitoes and act as sunscreen.

Bookshelf

Australian Frogs
Michael J. Tyler
Reed Books (1994)

This book includes chapters on general topics such as frog origins, fauna, classification, feeding, communication and development as well as specific subjects such as life above the ground, the cane toad and gastric brooding frogs.

A Field Guide to Frogs of Australia
Martyn Robinson
Reed Books (1995)

A Field Guide to Austrlian Frogs
J Barker, G.C. Grigg & M.J. Tyler.
Surrey Beatty and Sons (1995)

A Guide to the Stream-dwelling Frogs of the Wet Tropics Rainforests
Department of Zoology,
James Cook University (1994)

Printed on waterproof material, this booklet includes colour photos and descriptions of 12 species, including those which have disappeared.

Video:
Cane Toads — An Unnatural History
(46mins)
Mark Lewis Film Australia, Eton Rd, Lindfield, N.S.W. 2070. (1987)

Entertaining and informative, this is a wonderful film of 'a bizarre, biological blunder'.

Cane Toads — An Unnatural History
Stephanie Lewis
Dolphin/Doubleday (1989)

The book of the film. Well-illustrated, informative and entertaining.

Raising Native Frogs
Alastair Bax
Queensland Conservation Council
PO Box 12046, Brisbane, Q 4002
(1995)

In addition to giving construction methods for small 'instant' as well as conventional garden ponds, this booklet contains information on raising tadpoles and making frog houses and fly traps (for food).

Attracting Frogs to your Garden
Kevin Casey
Kimberley Publications, PO Box 6095
Upper Mt Gravatt, QLD 4122 (1996)

In addition to information on promoting frogs in the garden, this book has general information on frogs.

Australian Natural History Vol 24 No 5, Winter 1993
Frogwatch: To shun a silent Spring
Michael J. Tyler

Report on a survey of declining frogs Australia-wide.

Australian Natural History Vol 24 No 12, Autumn 1995
Frogs and drugs
Michael J. Tyler

A look at frogs as 'mobile pharmacies'.

Australian Geographic No 48 Oct. 1997
Spawn of an era
Matthew Cawood

A general article on Australian frogs.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
frog	Frosch	kaeru	蛙
tadpole	Kaulquappe	otamajakushi	おたまじゃくし
eggs	Eier	tamago	卵
disappear	verschwinden	shometsu suru	消滅する
toad	Kröte	hikigaeru	ひき蛙
beetle	Käfer	kochurui	甲虫類
larvae	Larven	yochu	幼虫
sugar cane	Zuckerrohr	satokibi	砂糖きび
poison	Gift	doku	毒
skin	Haut	hifu	皮膚

Mangrove plants

Mangroves — coping with salt

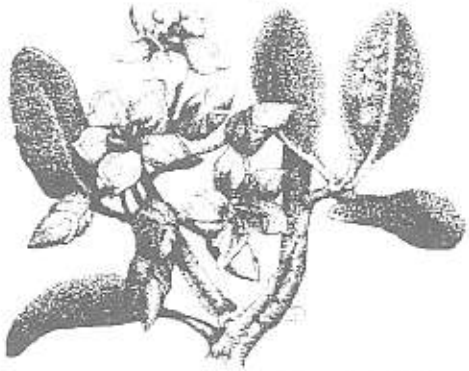
Mangroves are plants which live between the sea and the land. A mangrove is not a species, but rather the name given to a community of unrelated plants living in areas which are inundated by tides. Thus a mangrove may be a tree but (like a 'rainforest plant') may also be a shrub, palm, fern, climber, grass or epiphyte — all of them sharing the ability to live in salt water.

Do all mangroves *need* salt? It seems that the answer is no. Some species have been kept in pots where they have grown happily and flowered regularly when given only fresh water. However, experiments have also shown that the best growth occurs where the plants live in sea water diluted by about 50 percent with fresh water.

One particular advantage to growing in a salty environment is the lack of competition! Only a limited number of plants have invested evolutionary energy into adapting to such harsh conditions. In the optimum conditions of a tropical rainforest, diversity is great and competition fierce. On the edge of the sea (in Australia) about 30 species of mangroves have exclusive occupancy.

So how do mangroves manage to flourish in an environment which would kill most other plants?

The first line of defence, for many mangroves, is to **stop** much of the salt from entering at all by filtering it out at root level. Some species can exclude more than 90 percent of salt in sea water. (*Rhizophora, Ceriops, Bruguiera* and *Osbornia* species are all 'salt-excluders'.)



Crystals of salt can be seen on the leaves of the river mangrove (Aegiceras corniculatum)

Another trick, is to quickly **excrete** salt which has entered the system. The leaves of many mangroves have special salt glands which are among the most active salt-secreting systems known. It is quite possible to see and/or taste the salt on the leaf surfaces of species which choose this method. ('Salt-secreters' include *Aegiceras, Avicennia, Sonneratia* and *Acanthus*.)

A third method of coping with salt is to **concentrate** it in bark or in older leaves which carry it with them when they drop. (*Lumnitzera, Avicennia, Ceriops* and *Sonneratia* species all use this trick.)

As can be seen from the examples given, some mangroves use only one of these methods but many use two or more.

In addition, a number of features serve to **conserve** water. These include a thick waxy cuticle (skin on the leaf) or dense hairs to reduce transpiration — the loss of water. Most evaporation loss occurs through stomata (pores in the leaves) so these are often sunken below the leaf surface where they are protected from drying winds. Mangrove leaves are also frequently succulent, storing water in fleshy internal tissue.

Marvellous mangroves

Many people don't like mangroves, regarding them as muddy, mosquito- and crocodile-infested swamps. Their removal is seen as a sign of progress. So what is the point of preserving them? For a start, it has been estimated that up to 75 percent of fish caught commercially either spend some time in the mangroves or are dependent on food chains which can be traced back to these coastal forests.

Mangroves also protect the coast by absorbing the energy of storm-driven waves and wind. The only two yachts undamaged by Cyclone Tracy in 1974 had sheltered in a mangrove creek. While providing a buffer for the land on one side, mangroves also protect the sea on the other. Sediments trapped by roots prevent siltation of adjacent marine habitats where cloudy water may cause the death of corals. In addition, mangrove plants and sediments have been shown to absorb pollution, including heavy metals.

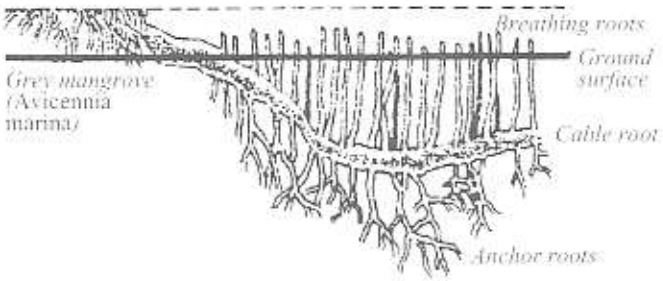
Worldwide, vast tracts of mangroves have been destroyed so we are lucky to have relatively large areas of Australia's tallest and best-developed mangroves still existing on our doorstep. A token preservation of small parts of these, however, would be similar to preserving just a few reefs. Now that their economic and ecological importance has been recognised we carry the responsibility to look after our mangroves.

Roots and shoots

Apart from coping with salt, mangroves also face common problems of water-logged, unstable and oxygen-deficient soils. Despite belonging to many different families mangrove plants have come up with surprisingly similar solutions.

Roots

Roots perform a number of functions for a plant. They support it and they obtain essential nutrients and oxygen.

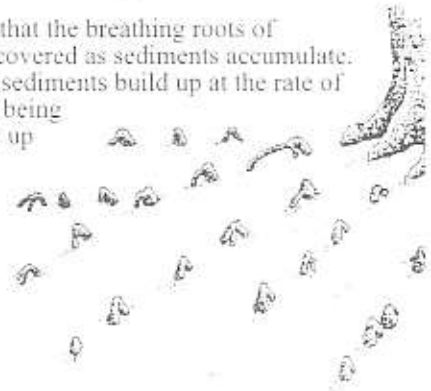


In unstable, sometimes semi-fluid, soil an extensive root system is necessary simply to keep the trees upright. As a result, most mangroves have more living matter below the ground than above it. The main mass of roots, however, is generally within the top two metres — mangroves do not seem to grow deep tap roots, probably because of the poor oxygen supply below the surface.

There are three types of roots with different functions. Radiating cable roots, punctuated by descending anchor roots, provide support. From this framework sprout numerous little nutritive roots which feed on the rich soil just below the surface. The third type of roots collects the oxygen.

Little oxygen is available in fine, often waterlogged, mud. The solution which many mangroves have come up with, is to raise part of their roots above the mud. These roots are covered with special breathing cells, called lenticels, which draw in air. They are connected to spongy tissue within the roots. When the roots are submerged in water, the pressure within these tissues falls as the internal oxygen is used up by the plant. The resulting negative pressure means that when the root is re-exposed, as the tide drops, more air is drawn in through the lenticels.

There is always a danger that the breathing roots of mangroves may become covered as sediments accumulate. Under normal conditions sediments build up at the rate of 1.5-2cm a year. To avoid being buried the roots can grow up vertically. Oil, however, can be fatal. Once covered with it the lenticels can no longer draw in air and the plant may suffocate.



Different mangrove species have developed different architectural designs to keep their roots in the air. The species shown here typify the different root arrangements.

Red (stilt or spider) mangrove

(*Rhizophora stylosa*) is commonly found close to the seaward side of mangroves. It is therefore subjected to high wave energy and has developed a system of stilt, or prop, roots. These spread far and wide, providing numerous anchors for the tree as well as a large surface area for oxygen-absorbing lenticels.

In common with other species, this mangrove also grows aerial roots, extra stilts which arise from the branches or trunk. Studies have shown that these aerial roots alter dramatically in structure when they reach the mud; above it they have about 5 percent air spaces but below this changes to 50 percent.

Grey mangrove

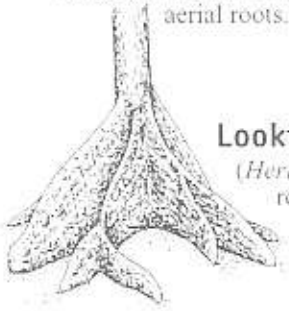
(*Avicennia marina*) grows a series of snorkels, or peg/pencil roots, known as pneumatophores. Experiments with a related *Avicennia* species have shown that those plants growing in coarse coral sand, with a good air supply to the roots, were able to survive after their pneumatophores were removed. However, those living in poorly aerated soil died when the pneumatophores were covered. In one situation, where they were covered with oil, the plants responded by growing aerial roots.

Orange mangrove

(*Bruguiera gymnorrhiza*) develops knee roots. These are cable roots which have grown above the surface of the mud and then down into it again.

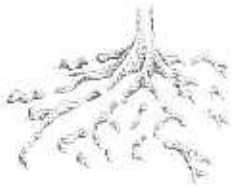
Looking glass mangrove

(*Heritiera littoralis*) produces buttressed roots which are like flattened, blade-like stilt roots.



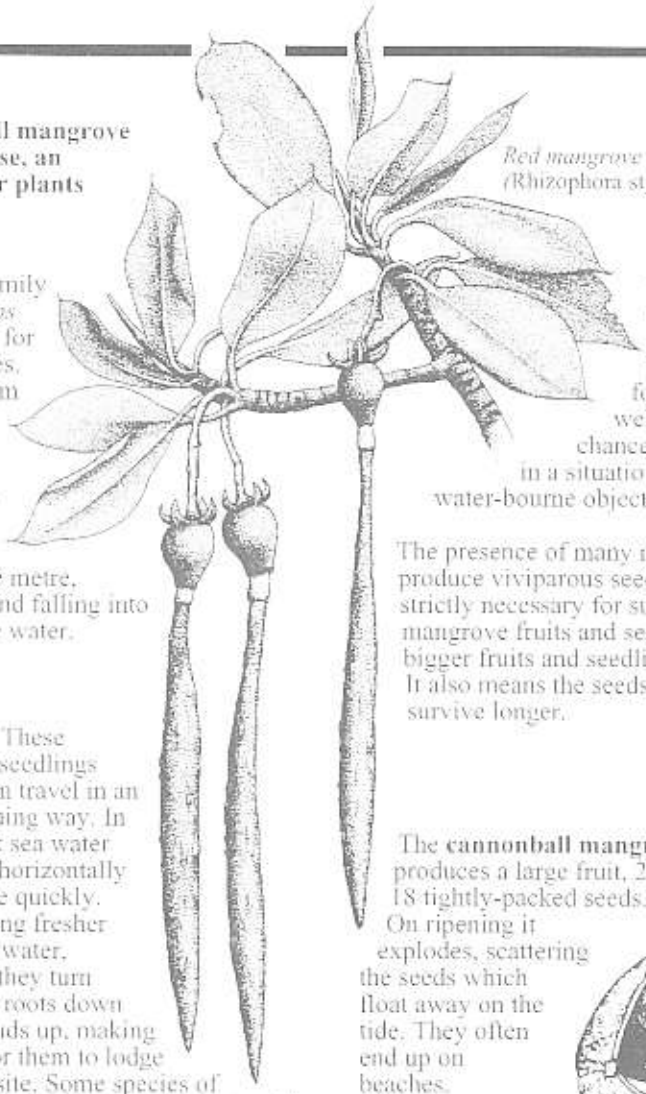
Cannonball mangrove

(*Xylocarpus granatum*) is buttressed but the cable roots also appear above the ground in the fashion of knee roots.



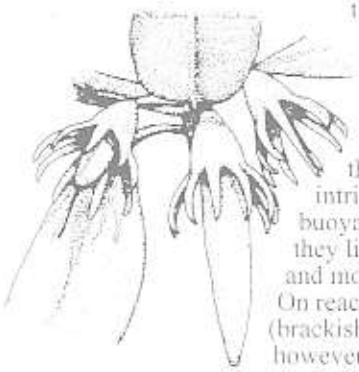
Shoots

The fruits and/or seed(ling)s of all mangrove plants can float, which is, of course, an excellent dispersal mechanism for plants which live in water.



Red mangrove
(Rhizophora stylosa)

Members of the Rhizophoraceae family (*Rhizophora, Bruguiera* and *Ceriops* species) have an intriguing method for successfully reproducing themselves. The fertilised seeds do not drop from the plants but begin to germinate, growing out from the base of the fruits to form long, spear-shaped stems and roots, called propagules. They may grow in place, attached to the parent tree, for one to three years, reaching lengths of up to one metre, before breaking off from the fruit and falling into the water.



Orange mangrove
(Bruguiera gymnorrhiza)

These seedlings then travel in an intriguing way. In buoyant sea water they lie horizontally and move quickly. On reaching fresher (brackish) water, however, they turn vertically, roots down and leaf buds up, making it easier for them to lodge in the mud at a suitable, less salty, site. Some species of these floating seedlings (*Rhizophora*) can survive, in a state of suspended animation, for up to a year in the water. Once lodged in the mud they quickly produce roots and begin to grow.

Some other species (*Avicennia, Aegialitis* and *Aegiceras*) also produce live seedlings but these are still contained within the seed coat when it drops from the plant. The seed of *Avicennia* floats until this coat drops away.

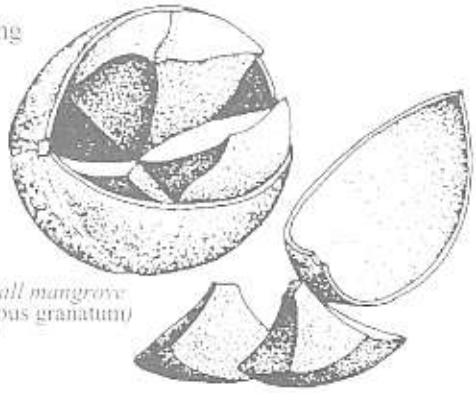
Grey mangrove
(Avicennia

Interestingly the speed with which this happens depends on the temperature and salinity of the water. In water of high or low salinity the seed coat is slow to drop off but in brackish water it is shed quickly allowing the seedling to lodge in the favoured habitat of this species. Higher temperatures also favour faster action. *Avicennia* seeds can stay alive for only four days in the water.

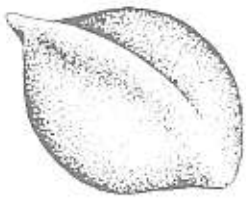
The production of live seedlings (known as vivipary) is very rare in plants other than mangroves and a few seagrass species and the reason for it is unclear. It is possible that the well-developed seedling has a greater chance of surviving, once it has taken root, in a situation where it is likely to be battered by water-bourne objects.

The presence of many mangrove species which do not produce viviparous seedlings shows that this strategy is not strictly necessary for successful reproduction. However, all mangrove fruits and seeds are large, which suggests that bigger fruits and seedlings have a better chance of survival. It also means the seeds with a big storage capacity may survive longer.

The **cannonball mangrove** (*Xylocarpus granatum*) (below) produces a large fruit, 20cm in diameter, containing up to 18 tightly-packed seeds. On ripening it explodes, scattering the seeds which float away on the tide. They often end up on beaches.



Cannonball mangrove
(Xylocarpus granatum)



The seed of the **looking-glass mangrove** (*Heritiera littoralis*) has a prominent ridge on one side. This may act as a sail when the seed is in the water.

Mangrove history

Red mangrove

It is thought that mangroves evolved somewhere between Australia and New Guinea, about 50-60 million years ago, and spread out from there to tropical regions worldwide. In warmer periods of the earth's history they probably covered a much larger area than they do now — mangroves currently growing in cool areas such as in Victoria and South Australia are probably relicts of that warmer time.

Desert plants of central Australia may also be seen as relict mangroves from the days when a vast inland sea covered the area. As it dried up, the plants which had adapted to those wet salty conditions found it relatively easy to adapt to a dry situation; salinity, in essence, causes drought by making it difficult to obtain water. As a result the water-conserving strategies of the two groups of plants, although separated by great distances, are remarkably similar.

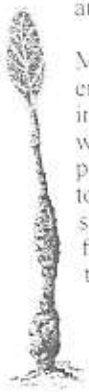
Orange mangrove

Where are the mangroves?

The necessities of life

The warmer and wetter the climate, the richer the mangrove community to be found there.

The most diverse mangroves occur in tropical areas where the water temperature is greater than 24deg. in the warmest month, where the annual rainfall exceeds 1250mm and mountain ranges greater than 700m high are found close to the coast. (The proximity of mountains tends to ensure the rainfall.) In addition, they need protection from high waves which can erode the shore and prevent seedlings from becoming established. In north Queensland the Great Barrier Reef performs this function while to the south a chain of sand islands provide shelter. Shallow, gently-shelving shores allow mangrove seedlings to anchor, particularly in estuaries, rivers and bays.



Mangroves exist in a constantly changing environment. Periodically the sea inundates the community with salty water while, at low tide, especially during periods of high rainfall, it may be exposed to floods of fresh water. Apart from suddenly altering the salinity levels, these fluctuations in water can alter temperatures as well.

Different mangrove species have different requirements. Some are more tolerant of salt than others. Other factors which affect their distribution include wave energy, soil oxygen levels, drainage and differing nutrient levels. Where one species finds its preferred conditions or at least those which it is able to tolerate better than other plants — it tends to become dominant. This has led to quite clear zones among mangroves.

Orange mangrove

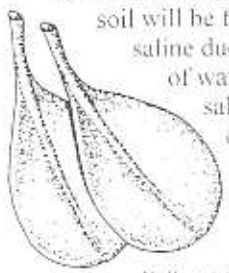
Zones in the mangroves

As a general rule bands of dominant mangrove species run parallel to the shoreline or to the banks of tidal creek systems. The seaward side of the community, where there is more salt water than fresh, is likely to be dominated by a fringe of grey mangroves (*Avicennia marina*). This tough species is Australia's most widespread due to its ability to tolerate low temperatures and a variety of conditions. A pioneer, it is likely to be the first species to grow on newly-emerged mud banks, putting up its distinctive peg roots. Mangrove apple (*Sonneratia alba*) often grows in this zone too.

Grey mangrove

The red (stilt or spider) mangrove (*Rhizophora stylosa*) is usually found behind this zone where its long prop roots give it a firm foothold in wind and waves.

The next zone may be inundated only by periodic spring tides at the time of the new and full moon. As a result the soil will be firmer but more saline due to the evaporation of water leaving behind salt which will not be diluted until the next spring tide. The tough yellow mangrove (*Ceriops*



Yellow mangrove

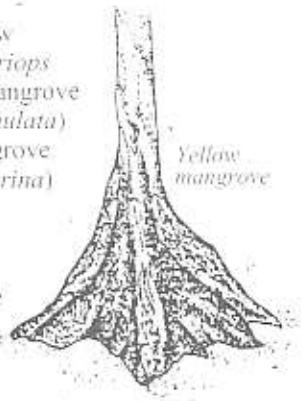
Orange mangrove

species) may be found in this zone, although conditions may make it impossible for anything other than succulent plants to thrive here. The resilient grey mangrove may appear again while less saline soils may be covered with a thick forest of orange mangroves (*Bruguiera* species).

A number of factors may determine what happens to the landward side of this zone. In conditions of high rainfall, such as exist in north Queensland, particularly in the Daintree, regular flooding may lead to freshwater swamp areas dominated by the less salt-tolerant mangrove species (such as freshwater mangrove (*Barringtonia acutangula*) and cottonwood (*Hibiscus tiliaceus*). Behind this may be a zone of paperbarks and the beautiful flaky-barked red beech or golden guinea tree (*Dillenia alata*), as littoral (shore) vegetation merges into rainforest.

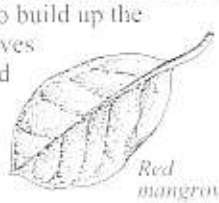
Cottonwood

In areas of very seasonal rainfall, such as those in the Gladstone to Townsville region, the reverse may be the case, evaporation and little fresh water input leading to an increase in salinity. This may be a salt marsh or salt flat zone where only the toughest mangroves (for example yellow mangrove (*Ceriops tagal*), club mangrove (*Aegialitis annulata*) and grey mangrove (*Avicennia marina*) grow.



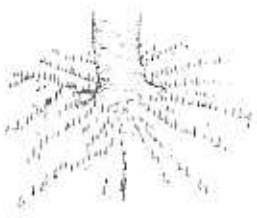
Yellow mangrove

There is a similar change of species along rivers, the zones corresponding roughly to decreasing salinity levels and ranges of salinity (among other factors). The ever-adaptable grey mangrove tends to be found throughout river systems, including the upper limit of tidal influence where fresh water is abundant. The greatest concentration of mangrove species is usually at the mouth of tidal creeks and rivers where salt and fresh water mix in ideal proportions and floodwaters deposit plenty of material to build up the banks. Red mangroves are frequently found here.



Red mangrove

While there are certain patterns to the development of mangrove zones, it must be remembered that local conditions will always dictate which mangroves are found where.

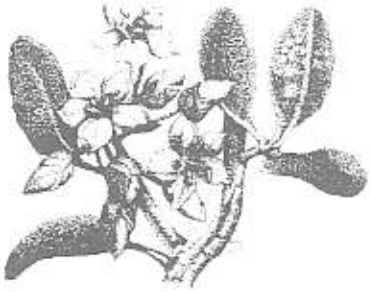


Grey mangrove

Mangrove uses

The mangroves have long functioned as a storehouse of materials providing food, medicines, shelter and tools.

Fish, crabs, shellfish, prawns as well as edible snakes and worms are found among the mangroves. The fruit of certain species, including the *Nypa* palm, can be eaten after preparation along with the nectar of some of the flowers. The best honey is considered to be that produced from mangroves, particularly the river mangrove (*Aegiceras corniculatum*) (below).



Numerous medicines are derived from mangroves. Skin disorders and sores, including leprosy, may be treated with ashes or bark infusions of certain species. Headaches, rheumatism, snakebites, boils, ulcers, diarrhoea, haemorrhages... and many more conditions are traditionally treated with mangrove plants. The latex from the leaf of the blind-your-eye mangrove (*Excoecaria agallocha*) can indeed cause blindness but the powerful

Blind-your-eye mangrove

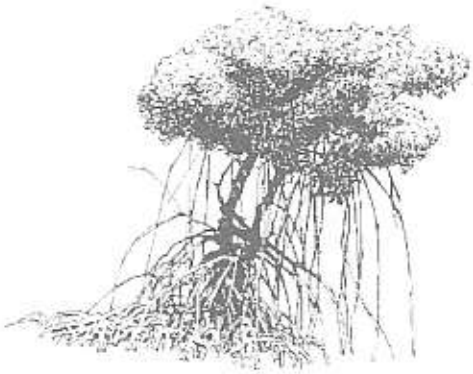
chemicals in it can be used on sores and to treat marine stings. They are also used for fishing; when leaves are crushed and dropped in water fish are stupefied and float to the surface. This sap is currently being tested for its medical properties and may play a part in western medicine.

Certain tree species, notably the cedar mangrove and the cannonball mangrove (relatives of the red cedar) as well as the grey mangrove are prized for their hard wood and used for boat building and cabinet timber as well as for tools such as digging sticks, spears and boomerangs. The fronds of the *Nypa* palm are used for thatching and basket weaving. Various barks are used for tanning, pneumatophores (peg roots) make good fishing floats while the wood from yellow mangroves (*Ceriops* species) has a reputation for burning even when wet.

Mangroves at sea

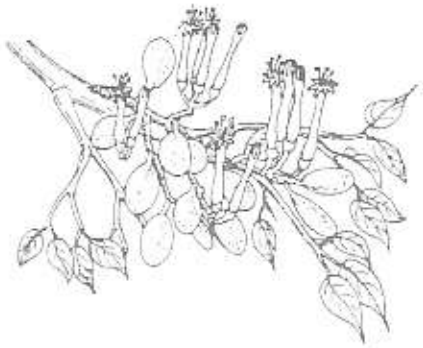
Mangroves occur not just on the coast of the mainland. They also pop up, where conditions are suitable, on the fringes of continental islands and on wooded coral islands of the reef. In these situations rainfall and nutrient levels are likely to be low so these communities generally lack the diversity and luxuriance of those on the mainland. (Very large islands, such as Hinchinbrook, are an exception.)

Mangroves of coral islands grow in an environment where the main sediment comes from coral and is thus high in calcium carbonate but low in the nutrients which come from the land. The more mature mangrove communities tend to become established on the sandier lee side, usually the northwest, while stunted forms of some species may grow elsewhere. Naturally, those species which require a greater degree of fresh water, are absent at sea.

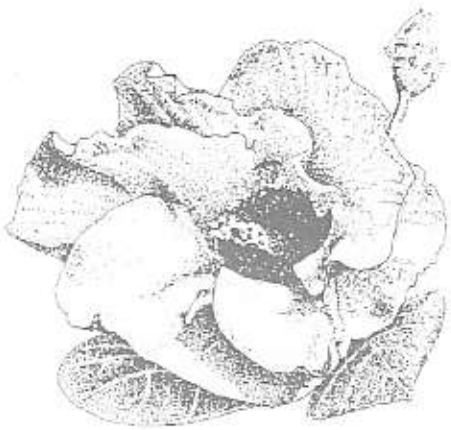


More plants of the mangroves

Like all ferns the **mangrove fern** (*Acrostichum speciosum*) has a relatively complicated means of reproduction. Spores are produced underneath the fronds in reddish-brown sacs. They are dispersed by wind and then develop into tiny plants (prothalli). These, in turn, produce reproductive structures which, in this species, depend on water for fertilisation. The result is a mature fern plant.



A number of **mistletoe** species live on mangrove trees, parasitising their hosts by sending special roots into their living tissue and robbing them of nutrients. Mistletoes also gain nourishment by photosynthesising, so grow well where sunlight is available. Some species grow only on mangroves while others may be found on other types of trees as well (and some species are never found on mangroves). Since all mangroves contain a high salt content in their sap those mistletoes which choose them for hosts have had to adapt themselves appropriately.



Known as **cottonwood** or river mangrove, this native hibiscus (*Hibiscus tiliaceus*) is a marginal mangrove species, growing on the landward side of mangroves where fresh water is abundant. The underside of its leaves are densely covered with hairs which may help to conserve precious water by reducing loss through transpiration.

Facts and stats

on mangrove plants

Worldwide there are 69 recognised species of mangrove plants belonging to 20 families. Up to 34 mangrove species and three hybrids are known to occur in Queensland — although figures may change as the definition of a mangrove is not clearcut and some plants, such as cottonwood, may be regarded as a mangrove by some and not by others.

A study of Cairns mangroves found 24 mangrove tree and shrub species while a further 18 species of flowering plants were growing among the mangroves or on salt marshes. An additional 42 species of epiphytic plants and 25 species of fungi were identified growing on the mangroves.

No mangrove species are restricted only to Australia. Many occur widely throughout the Indo-West Pacific region. Some, such as the red mangrove (*Rhizophora stylosa*) are, however, best developed in Australia.

The north-east coast of Australia is home to the greatest diversity of mangroves and associated plants. This is because this region was close to the centre of origin and dispersal of mangroves, because the climate is similar to that under which they first evolved and because the sheltered shallow waters of numerous estuaries are ideal for growth.

Mangrove forests occupy approximately 11,600 square kilometres in Australia, 4,600 of these being in Queensland.

The origin of the name 'mangrove' is not certain. It may be a combination of the Portuguese 'mangue', meaning an individual mangrove tree, with the English 'grove', although early versions were 'mangrowe' and 'mangrave'. It may also be derived from the Malay 'manggi-manggi' or 'mangin'.

The colours included in the common names of many mangrove trees often refer either to the bark (for example, grey mangrove) or to the blaze — the colour which shows when the bark is scraped — (for example, the red mangrove).

Bookshelf

Field Guide to the Mangroves of Queensland
Catherine Lovelock
Australian Institute of Marine Science (1993)

This useful pocket-sized guide shows 22 species of mangrove plants illustrated in full colour, with identification notes, as well as giving some good background information.

Mangroves in Focus
Dave Claridge and John Burnett
Wet Paper Publications (1993)

This book presents a great deal of information, in an easy-to-read format, on the mangrove environment, its values and threats. One chapter gives species descriptions while the final section is full of activities, games and ideas for excursions and projects making it particularly useful for schools.

Ecology of Mangroves
Patricia Hutchings and Peter Saenger
University of Queensland Press (1987)

Intended for the scientist this very comprehensive book is packed with information.

Mangroves of Australia
Richard Lear and Tom Turner
University of Queensland Press (1977)

Although out of print now this excellent little book is still available in libraries.

Mangrove Boardwalk to Myall Beach, Cape Tribulation
Esther Cullen (1994)

This useful and thorough guide is available from the Department of Environment office at Cape Tribulation.

Mangroves of the Northern Territory
Glenn M. Wightman
Conservation Commission of the Northern Territory (1989)

Many species described in this book also appear in Queensland. Many of the notes on each species include interesting Aboriginal uses.

Mangroves in New South Wales and Victoria
Christopher Harty
Vista Publications (1997)

Although not covering Queensland, there is also good general mangrove information in this book.

Tourist talk

ENGLISH	GERMAN	JAPANESE
mangrove	Mangrove	マングローブ
salt water	Salzwasser	en sui 塩水
fresh water	Süßwasser	tan sui 淡水
exclude	ausschließen	shya dan suru 遮断する
secrete	absondern	bun pi suru 分泌する
air	Luft	ku ki 空気
leaf	Blatt	ha 葉
root	Wurzel	ne 根
seedling	Samen, Trieb	waka gi 若木
float	treiben	ukabu 浮かぶ

Mangrove animals

The flora and the fauna

A teaspoon of mud from a North Queensland mangrove contains more than 10 billion bacteria. These densities are among the highest to be found in marine mud anywhere in the world and are an indication of the immensely high productivity of this coastal forest habitat.

Mangrove plants produce about one kilo of litter (mainly leaves, twigs, bark, fruit and flowers) per square metre per year. Some of this is consumed by crabs but most must be broken down before the nutrients become available to other animals. That is where the bacteria, along with fungi, come in. Dividing sometimes every few minutes, they feast on the litter, increasing its food value by reducing unusable carbohydrates and increasing the amount of protein — up to four times on a leaf which has been in seawater for a few months.

Partly decomposed leaf particles, loaded with colonies of protein-rich micro-organisms, are then eaten by fish and prawns. They in turn produce waste which, along with the smallest mangrove debris, is munched up by molluscs and small crustaceans. Even dissolved substances are used by plankton or, if they land on the mud surface, are browsed by animals such as crabs and mud whelks.

This process is not confined to the mangroves. While some litter is recycled on the spot, this system is one of the few to export much of the organic matter it produces. Every time the tide retreats it carries a cargo of food out to sea. Studies of the mangroves at the northern end of Hinchinbrook Island have shown that they export more than 12 500 tonnes of litter per year into the Great Barrier Reef lagoon. This material is deposited over an area of 260 square kilometres of seabed. Here bacteria densities are almost as high as those in the mangrove mud and they do much the same job, breaking down the litter to be consumed by bottom-living fauna, by prawns and fish.

The seafood industry is the fifth largest primary industry in Queensland, with an annual commercial catch worth around $250 million. An estimated 75 percent of commercially caught fish and prawns depend directly on mangroves at some time in their lives or feed on food chains leading back there. Since those species making up the remainder of the catch probably also owe much to nutrients exported from the mangroves, these coastal forests can be seen as one of our major assets.

Where d'ya reckon all the fish have gone?

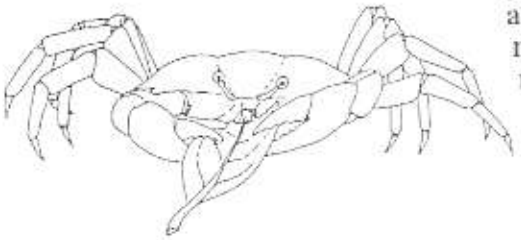
The white-bellied sea-eagle is a top predator in the mangrove food chain.

Integrated systems

Although mangrove plants and animals are being dealt with in two different chapters, to divide up an ecosystem in such a way is very artificial. Plants and animals are intimately related and their interdependence is no less a feature of the mangroves than of other ecosystems. Animals pollinate the flowers but eat seedlings and foliage. They shelter among branches or among roots where their burrows improve the soils. They prune growing tips but enrich the soil with their droppings. They damage living leaves but feed on discarded ones, recycling the nutrients.

By the same token, ecosystems do not exist in isolation from each other. Organisms in the mangroves become components of food chains which reach far beyond their boundaries, linking one system to another.

Crustaceans in the mangroves

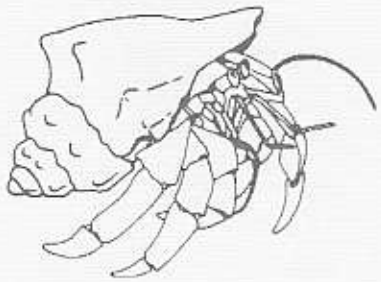


Of all the animals in the mangroves the crustaceans — crabs, prawns and shrimps — are probably the most conspicuous and among the most intriguing. There are at least 70 different species in Australian mangroves, of which about 65 percent are crabs.

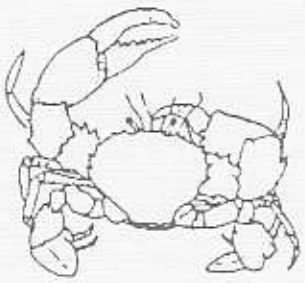
Many crustaceans in the mangroves make burrows which are used for refuge, for feeding, as a source of water or for establishing a territory necessary for mating. Some may filter water through their burrows, feeding on suspended detritus and plankton, while others may breed there. Certainly these burrows play an important role in the mangroves, aerating, draining and turning the dense waterlogged soil — a direct benefit to the plants which in turn give them shelter.

There is a limit to how many burrows can be dug in any one area. It seems that when there are too many burrows, homeless crabs may try to take over occupied ones. Some fiddler crabs and ghost crabs have been observed filling in the burrows of their neighbours to maintain their territories! Like other burrowing mangrove creatures, many crabs tend to be nocturnal, the majority appearing at night on a rising tide and remaining in their burrows by day to avoid predatory birds. Fiddler crabs are a notable exception.

Among mangrove roots, the obvious mud towers, up to 75cm high, belong to the **mud lobster**, or mud prawn. Underneath the mound its U-shaped burrow extends up to 1.5m below the surface. Since it is beneath the water table there is always a pool of water at the bottom enabling this animal to live quite far up the shore. Entrances to its mound are usually blocked by day with a mud plug, the lobster feeding on surface mud at night. This crustacean plays a significant role in turning over and oxygenating mangrove mud. Its mounds are home to high numbers of polychaete worms.



Hermit crabs are a familiar sight in their borrowed shells; they are the mud whelks which move too fast! Mangrove species feed largely on surface detritus, unlike species elsewhere which feed on larger items.

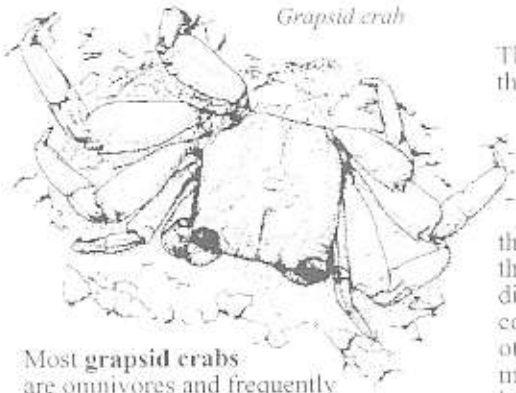


After mating, female **mud crabs** migrate up to 30km offshore and to depths of 300m to spawn. The larvae eventually drift inshore, moult and, as juvenile crabs, burrow into the substratum of mangroves and seagrass beds. As adults they move to the mudflats, using mouth parts to crush food such as molluscs or small crabs and powerful claws for larger prey. Mud crabs are largely nocturnal.

Two crab families

Mangrove crabs in northern Australia come from two main families, the grapsids and the ocypodids. Grapsids have a broad front with eyes on short stalks, a square mouth frame and a marked gap between the claws. The latter, including the fiddler crabs, have long eye stalks situated closer together, a mouth frame which is not so square, and closer claws.

Grapsid crab



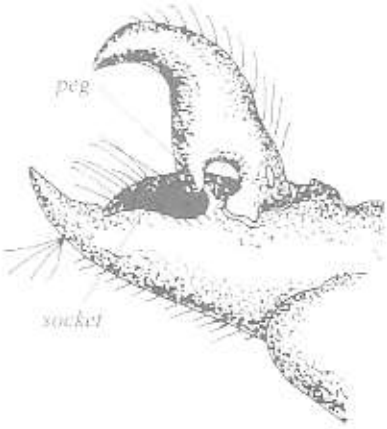
Most **grapsid crabs** are omnivores and frequently collect fallen mangrove leaves, sometimes fighting over them before dragging them into their burrows to feed. It is not known how leaf-eating crabs deal with the high tannin content in the leaves, a deterrent to most other animals. They may choose leaves which have had the tannins leached out, or species with low tannin levels, or they may be physically adapted to deal with them. These crabs play an important role in the recycling of nutrients in the mangrove system although, on the other hand, they are also a major consumer of mangrove seedlings. They also represent one link in a rather short and efficient food chain, eating mangrove leaves and being eaten by predatory fish — which are in turn preyed upon by us.

Although grapsid crabs, like fiddlers, build burrows, they do not retire underground when the tide comes in, climbing up mangrove trunks instead to avoid marine predators. Their burrows are used primarily as dining rooms.

The majority of **ocypodid crabs** feed on the nutrient-rich surface mud or sand. The grains are scooped up, rolled around in their mouth cavity and stripped of any slime and bacteria coating the particles by specialised feeding hairs. The fineness of these hairs dictates where on the shoreline the crabs can live and for this reason different species are found in different zones. Some species have very coarse hairs only suitable for sand, while others have finer hairs and do best on muddier substrate. Once the food particles have been removed the remains are spat out as small round balls. As many different types of crabs feed in the same way, these small round balls are a common feature around crab burrows. Most crabs arrange the balls radially, leaving clear paths back to their burrows in case they need to retreat quickly.

Mangrove crabs are adapted to living out of water for relatively long periods. Certain ocypodid species retain water in their gill chambers, replenishing it regularly in pools of water or in burrows. Some fiddler crabs do this by squatting in water and absorbing it through an opening between the third and fourth legs. Some crabs simply reoxygenate the water in their gill chambers as it gets stale, by passing air through it or by cycling it over the shell and back to the gill chamber.

Many mangrove crustaceans have thickened shells to reduce evaporation. This would also give them some protection from predatory birds.



A characteristic noise of the mangroves is a loud crack or pop produced by the rarely seen **pistol shrimp** which inhabits the more fluid soils in wetter parts of the mangroves. The sound is produced by the animal snapping its enlarged claw which contains a unique peg and socket arrangement. It is thought to be a territorial signal and/or a noise made to deter predators.

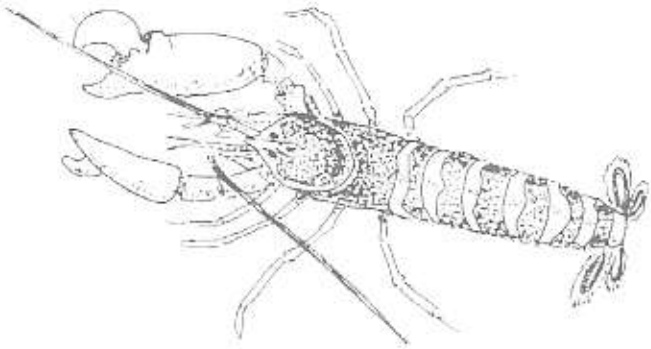
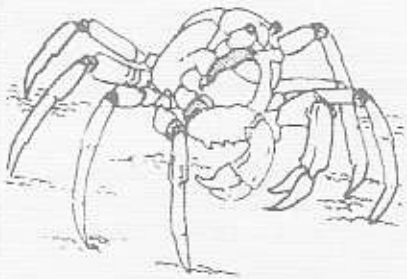


Illustration courtesy Esther Cullen



Distinctive blue-shelled **soldier crabs** form 'armies' sometimes thousands strong as they move around the tidal flats feeding on surface sediments. They are fairly unique among crabs in that they walk forwards instead of sideways. Preyed on by a number of animals they can quickly vanish into the mud using a distinctive 'corkscrew' burrowing technique. Before high tide each crab builds an igloo-like convex mound over its burrow. When the tide recedes again they emerge one by one until large numbers of them appear on a previously empty beach. Juvenile soldier crabs frequent mangroves and seagrass beds while adults prefer nearby mudflats.

Focus on fiddlers

Fiddler crabs are some of the most colourful animals found in mangrove forests. There are about 70 species worldwide. Although they can be found at quite high latitudes in North America, in Australia they are more common in warmer areas, about a dozen occurring along the Wet Tropics coast. As fiddlers are quite small (usually less than 8cm across their backs) and easily disturbed, people rarely get a close look at them. The shadows of birds overhead will often trigger retreat by a whole community. Your shadow will have the same effect; only by sitting quietly can the fascinating social behaviour and vivid colours of these little crabs be appreciated. The jewel-like colours of some species have given rise to common names such as 'Darwin red legs', also known as *Uca flammula* which translates as 'little flame'.

The movements of the male's enlarged front claw, which can be on either the left or right side, gives the name to the group. Waving movements can be either in a beckoning or an up-and-down motion. As the female fiddlers do not have a large claw, they can be mistaken for another crab species, but their similar carapace (shell) colour gives them away.

Each fiddler crab species has developed a distinct stereotypical wave which is the signature for that species. The purpose of male claw waving has been a topic of debate among crab specialists for years. As males wave vigorously at other males moving close to their burrow entrances, territorial aggression has been postulated. However, males also wave at females prior to mating, thus waving also appears to play a part in courtship. Female crabs are very discriminating and will only mate with males which wave in the correct manner for their species. Males, however, will attempt to mate with any crab wandering past, even other males which have lost their large claw!

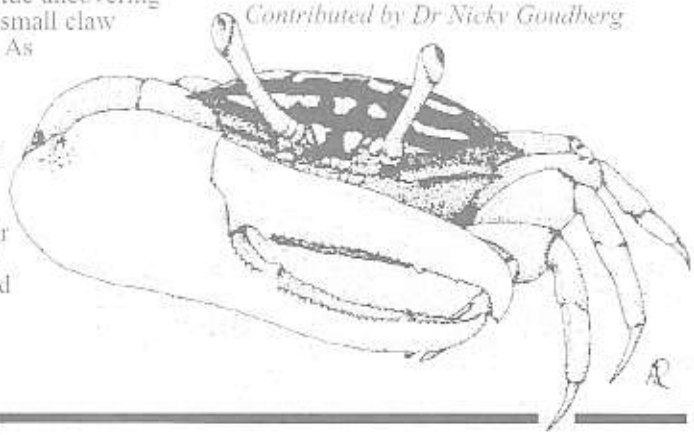
Claw loss due to fighting is infrequent as fighting is a highly ritualised process which rarely leads to physical contact — a bit like crab tai-chi.

During the high tide period the crabs remain down their burrows to avoid being eaten by predatory fish. They emerge to feed and socialise within about 30 minutes of the daytime tide uncovering their hideouts. Only the small claw can be used for feeding. As females have two of these they can feed at a faster rate than males. Because large males are often found to be in a poor condition, it is thought those with larger claws can't feed enough to maintain their size and may starve as a result!

Fiddler crabs have inbuilt clocks set according to the tides. This is demonstrated by their tendency to change colour. At low tide their normally brown legs become pale and their dark shells change colour. Some species turn blue while others develop orange or white markings. Only their claws remain the same. Young fiddlers also become pale at low tide. Experiments have shown that they continue to change colour in time with the tides even when removed from the marine environment and kept in aquaria.

When the weather is cool or the tide is coming in the crabs cease feeding, excavate a mud cap and retire to their burrows, placing the cap over the entrance as they go. These caps are so expertly sized and placed that the burrows disappear and are very difficult to relocate until emergence at the next low tide.

Contributed by Dr Nicky Goudberg

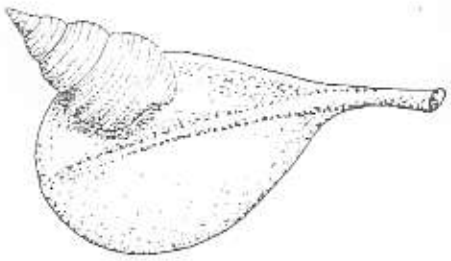


Life in the mangroves — animals of land and sea

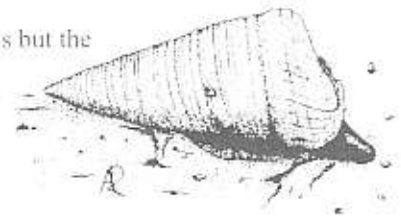
Situated as they are, between land and sea, mangroves provide food and shelter for animals from both worlds. While some are permanent residents, the majority are visitors, choosing certain times of day, tides or seasons or appearing at particular stages of their lifecycles, during migrations, for breeding or at times of stress such as droughts.

For marine animals, mangroves offer abundant food and protection from predators and from the hot dry sun. For terrestrial animals the habitat may simply function as an extension of their normal one. They are restricted, however, by a lack of fresh water and most herbivores are probably discouraged by the high levels of tannin and salt in mangrove leaves. However, seafood forms an important part of some diets while trees may provide food, such as nectar, in certain critical seasons. In addition, a reduction in numbers of predators or competitors may make mangroves an important habitat for breeding or roosting.
Here we look at some residents and visitors.

Mud whelks (below) are common snails on the surface of the mud where large numbers feed on algae and detritus. Often the lower surface of the shell is worn away, possibly corroded by the acidic mud.

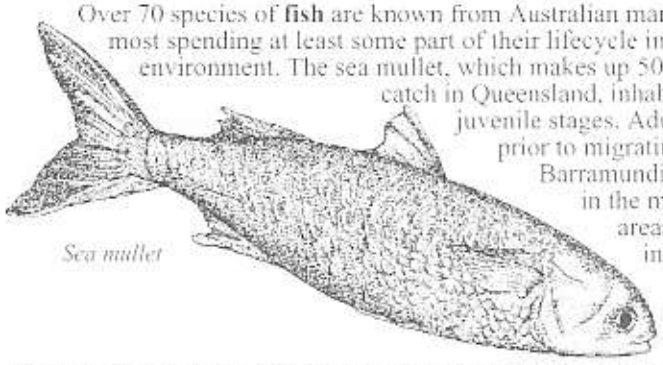


Most marine molluscs breathe with the aid of gills but the ***Onchidium*** has instead developed a lung which enables it to breathe air — through its anus. Thus able to live out of the water, this slug can be found on the trunks and aerial roots of mangrove trees and on the mud surface. With its dark brown, bumpy skin, it blends so well as to be almost invisible.



Some **snails** (above) live on the trunks and leaves of mangrove trees where they feed on microscopic plants. Some choose quite specific habitats, such as the leaves of only one species of tree. The juveniles of the common *Littorina scabra* tend to be found at the lower levels, near to the water. Here dark-coloured individuals are more common, lighter ones being more readily picked off by fish. Adults, however, are more frequent in the canopy where they develop a yellowish colouration, a camouflage which protects them from hungry birds. Some mangrove snails, when disturbed, drop off the leaf and suspend themselves by a thick mucous cord.

Over 70 species of **fish** are known from Australian mangrove creeks and rivers, most spending at least some part of their lifecycle in that protective environment. The sea mullet, which makes up 50 percent of the commercial catch in Queensland, inhabits the mangroves in its juvenile stages. Adults also assemble there prior to migrating out to sea to spawn. Barramundi, on the other hand, spawn in the mangroves and inshore areas, the juveniles developing in estuaries before moving up the rivers.



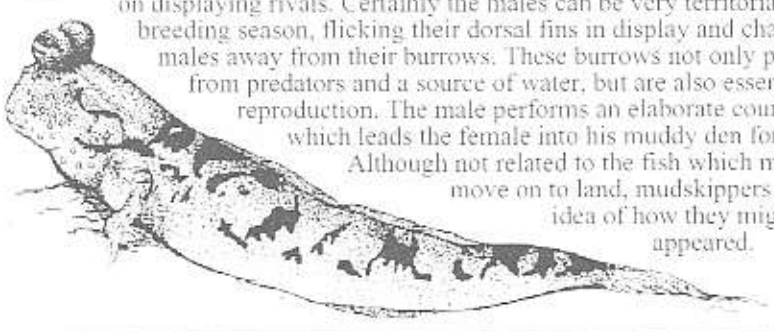
Sea mullet

Mudskippers are one of the few fish which live only on tropical mangrove shores where their skittering movements are a typical sight. Often this is the first we see of them; they are well-camouflaged and able to change colour to match their background.

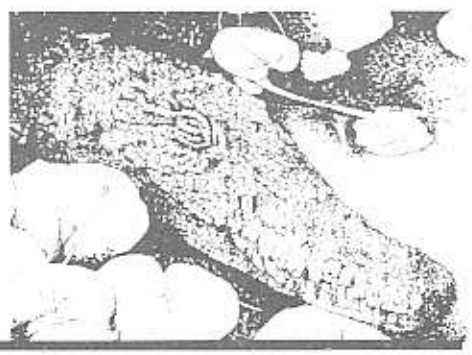
When submerged a mudskipper swims like any normal fish but out of water its specialised skeleton and muscles allow it to use its pectoral (front) fins as crutches, stretching them forward and swinging its weight on to them. The skipping movement is achieved by bending its tail forward to one side and propelling itself forward. Some species can climb, using their fused pelvic (rear) fins as suckers and their pectoral fins as grasping 'arms'. In water a mudskipper can skim across the surface, flying-fish style.

When a mudskipper is out of water it carries, in its expanded gill chamber, a reserve from which to extract oxygen. After a few minutes, when this reserve is exhausted, it is replenished from pools or from water in burrow. The mudskipper's mobile eyes bulge up from its head allowing it a wide-angle view which helps it locate prey (spiders, insects, crabs, worms, molluscs, and so on) and to spot predators. They also act as periscopes for the submerged fish. On land, the eyes are moistened, from time to time, by being 'blinked' down and immersed in a pool of water in the sockets.

Studies have shown that the upper half of the eye has many more rods (for vision in poor light) while the lower half is much richer in cones (for colour vision). It has been suggested that the upper part is used for spotting prey while the lower part keeps watch on displaying rivals. Certainly the males can be very territorial during the breeding season, flicking their dorsal fins in display and chasing other males away from their burrows. These burrows not only provide refuge from predators and a source of water, but are also essential for reproduction. The male performs an elaborate courtship dance which leads the female into his muddy den for mating. Although not related to the fish which made the first move on to land, mudskippers give us some idea of how they might have appeared.



Marine borers, a favourite Aboriginal food, are very abundant molluscs in logs where their tunnels and cavities create habitats for other animals. They are important decomposers of the wood.



Insects are the most diverse and numerous of all animal groups in the mangroves. For many this forest is simply an extension of their terrestrial habitat but some are found nowhere else.

A boring **beetle**, *Coccotrypes fallax*, lays its eggs inside *Rhizophora* propagules (seedlings). Just as they are becoming established in the mud, many of them can be seen drooping because of the larvae eating them within. Once the beetles have pupated they bore their way out of the propagule leaving it looking as if it has been attacked with a shotgun. Males are very rare, shortlived and never leave the propagule. Unmated females can reproduce, a strategy adopted by certain insects where adverse, but stable, conditions mean that the adaptations which come with sexual reproduction are not a high priority.

Various species of **ants** are known from mangroves. Those which live at ground level are apparently able to trap air in their burrows with plugs of mud at high tide.

Some species of **flying fox** roost in the mangroves and nearby paperbark swamps. In the Wet Tropics black flying foxes, little red flying foxes and spectacled flying foxes (right) congregate in sometimes huge camps. Although they range far and wide at night in search of food, along with blossom bats, they feed on mangrove flowers, particularly mangrove apple, *Sonneratia alba*, in season.

Pied imperial-pigeons nest in mangroves.

Over 230 species of **birds** have been recorded in mangroves in Australia but numbers at any one time tend to be low, most being occasional visitors. Some, such as honeyeaters and lorikeets, may appear during the flowering season, in search of nectar, while others seek fruit or insects. Others may arrive during migrations or, like the pied imperial-pigeon, for breeding. A large number of visitors are wetland birds which feed on adjacent mudflats and estuaries but use the mangroves for shelter — for roosting and/or breeding.

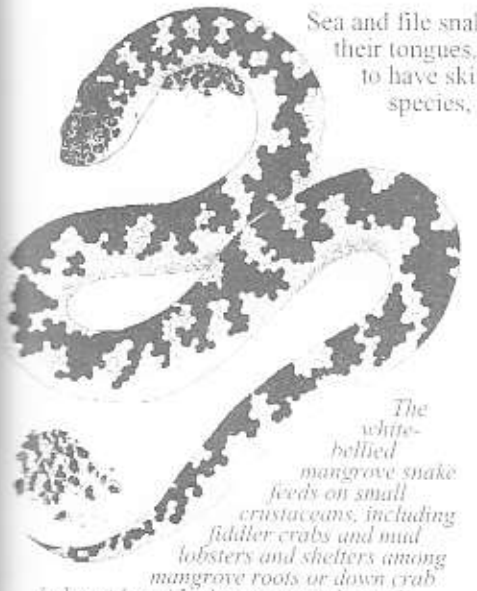
The dusky honeyeater is a frequent visitor.

Only about eight bird species are restricted to mangroves in the Wet Tropics. It has been observed that many of these have longer bills than closely related species from elsewhere. It is thought this may prevent them from getting dirty faces while foraging on the mud surface.

The mangrove heron, a resident, feeds on crustaceans and mud skippers.

Sea **snakes**, especially the banded sea krait, visit on high tides. Species of a more terrestrial origin which are found predominantly in the mangroves include the little file snake, the mangrove snake and the white-bellied mangrove snake (below). Pythons are attracted by large camps of flying foxes.

Sea and file snakes excrete salt from glands at the base of their tongues. In addition, snakes from the mangroves tend to have skins which are less permeable than other species, thereby stopping salt from entering.



The white-bellied mangrove snake feeds on small crustaceans, including fiddler crabs and mud lobsters and shelters among mangrove roots or down crab holes at low tide. It may enter the crab burrows in search of prey.

Estuarine crocodiles come into the mangroves on the rising tide to feed. Juveniles eat crabs, prawns, mudskippers and other small fish while older animals feed on large mud crabs, birds and mammals. They do not generally nest in the mangroves but on the banks of adjacent rivers. Estuarine crocodiles have salt-secreting glands at the back of their tongues which enable them to survive indefinitely without drinking fresh water.

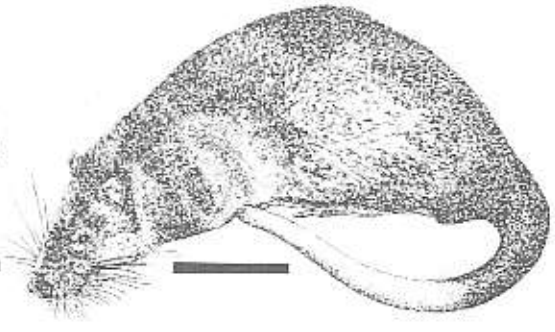
Monitor lizards, notably the mangrove monitor and the rusty monitor, frequent mangroves to feed on insects, fish, crabs and birds.

Few mammals live permanently in the mangroves. A notable exception is the very rare **false water rat**, a colony of which inhabits the mangroves of North Stradbroke Island. Small, grey with a white belly, it travels up to 3km a night feeding on crabs which it disables by biting off first the eye stalks and then the claws. Each individual protects a territory of about a hectare, fighting intruders if necessary. Despite its habitat this little rodent has no webbing on its feet and doesn't appear to like getting wet. It builds a mound of mud and leaves, honeycombed with tunnels, with a nesting chamber at the top. Researchers have suggested the new, and more appealing, name of 'water mouse' for this unusual little mammal.

The much more common **water rat** (right) sometimes builds its nest near to mangroves, feeding on crustaceans, fish and even young water birds. Unlike its little relative, it has partly webbed feet.

Bities in the mangroves

Biting midges, commonly but mistakenly known as sandflies, breed in quite restricted zones, necessary conditions differing according to species. The developing larvae mustn't dry out — or get too wet or they may drown. Despite the limitations, suitable sites are intensely used. Mangroves may allow midges to travel (the greatest distance travelled by a midge is 1.6km) but are not particularly good breeding sites for most species. In fact, cleared mangrove sites are much more suitable, some canal estates having proved perfect for certain species of this pest! **Mosquitoes** breed in quiet pools at the back of the mangroves particularly if disturbance such as dredging and filling has created stagnant pools.



Facts and stats

on mangrove animals

At least 100 species of molluscs are found in Australian mangroves. About 75 percent of these are gastropods (snails) the remainder being bivalves. The best-known of these is probably the mangrove oyster which colonises the trunks and aerial roots of the trees in large colonies.

In a 1970s study of animal species in the Cairns mangroves 54 molluscs, 76 crustaceans, 30 insects and 42 spiders were collected. A more recent study of species found in the Daintree, Endeavour and Russell/Mulgrave estuaries listed 13 mammals, 100 birds, numerous insects, 28 spiders, 23 reptiles, 3 amphibians, 33 fish, 47 crustaceans and 39 molluscs.

At least 24 species of polychaete worms are known to live in the mangrove substrate.

An upside-down jellyfish is common in north-eastern Australian mangroves. Although it can swim it generally lies upside-down on the substrate with its tentacles waving in the water, rather like an anemone. Like most hard corals, this jellyfish contains symbiotic zooxanthellae (algae) in its tissues which benefit from the sunshine in shallow water and help supplement their host's diet.

Fiddler crabs can fold their long eye stalks into slits at the side when they crawl into their burrows.

Pollination of most mangrove plant species is achieved with the help of birds, insects and wind. Bees are particularly important and can produce excellent honey from their visits. The flowers of mangrove apple (*Sonneratia*) and fresh-water mangrove (*Barringtonia*) open at dusk and are pollinated by moths and bats.

Wallabies, bandicoots, antechinus, possums, dingoes, pigs and cattle as well as a number of rodent species have all been known to visit mangroves, usually at low tide.

Bookshelf

See the bookshelf section of the previous chapter for general mangrove books.

The Reader's Digest Book of the Great Barrier Reef
Reader's Digest Services Pty Ltd

This book contains a chapter on mangroves and has references to mangrove inhabitants in other sections (check the index). It also describes the formation of low wooded islands, of which mangroves are an intergral part.

Tropical Mangrove Ecosystems
A.I. Robertson and D. M. Alongi (eds)
American Geophysical Union (1992)

An academic collection of papers, this book looks at all aspects of mangrove systems. Almost all the contributers to this book have been associated with the Australian Institute of Marine Science at some time so the focus is on local mangroves.

The Mud Crab
D.F.Fielder and M.P.Heasman
A Queensland Museum Booklet No. 11 (1978)

A very interesting and readable booklet on this one crustacean deals with its biology as well as catching and cooking.

Hermit Crabs of the Great Barrier Reef and Coastal Queensland
Christopher C. Tudge
Backhuys Publishers (1995)

This is useful as an identification guide to the most common species and has a key, descriptions and 24 colour photos.

Reader's Digest Complete Book of Australian Birds
Reader's Digest Services Pty Ltd

This is a good source of information on all birds, including those found in mangroves.

Crocodiles of Australia
Grahame Webb and Charlie Manolis
Reed Books Pty Ltd (1989)

This superb book is a must for anyone wanting to learn more about these animals.

Reptiles and Amphibians of Australia
H.G. Cogger
Reed Books (1992)

Snakes and lizards found in the mangroves are included in this 'bible'.

Australian Fishery Resources
Patricia J. Kailola, *et al*
DPI (1993)

A comprehensive reference to marine and freshwater species taken in commercial and recreational fisheries in Australian waters.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
bacteria	Bakterien	bacteria	バクテリア
nutrients	Nährstoffe	eiyo bun	栄養分
crab	Krabbe	kani	蟹
mud skipper	Schlammspringer	mutsu goro	ムツゴロウ
mud whelk	Schlammschnecke	bai gai	ばい貝
shrimp	Garnele	ko ebi	小エビ
snail	Schnecke	katastumuri	カタツムリ
fish	Fisch	sakana	魚
crocodile	Krokodil	kurokodairu	クロコダイル
pollination	Befruchtung	jufun	授粉

Fire

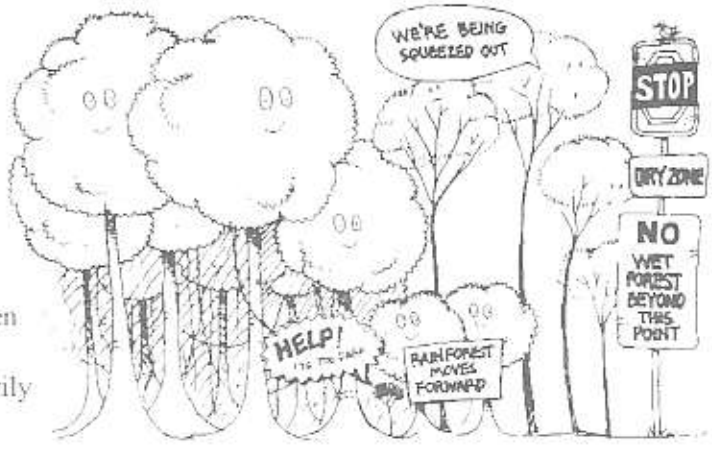
Rainforest invasion

A few years ago, one of our rangers discovered a dragon on the Cape Tribulation headland. It was not a fire-breathing monster but nonetheless it gave him quite a shock because it was a species, the two-lined dragon (*Diporiphora bilineata*), which is common in dry areas, particularly around Mt Carbine and Mt Molloy, but not at Cape Tribulation! Found in a patch of heathland, this little reptile is probably a relict left over from a time when, due to Aboriginal burning, the area had more sclerophyll woodland. Well within living memory goats grazed on Cape Tribulation. Areas north of Emmagen Creek are marked on an 1890 survey map as 'magnificently grassed flat'.

It has been estimated that rainforest, in some areas, is expanding at the rate of 1.25m per year. This sounds like good news until we look at some of the habitats it is taking over. Wet sclerophyll forest has similar requirements to rainforest, particularly with regard to rainfall. It is generally found on the western margins of rainforest and in isolated pockets such as hill tops but cannot exist on drier areas where dry sclerophyll forest takes over. Unlike rainforest, however, trees of the wet sclerophyll, such as flooded gum (*Eucalyptus grandis*), need open well-lit conditions to germinate and develop. Where rainforest species are moving in and forming a dense cover, shady conditions mean that eucalypt seedlings cannot establish themselves. An area where invasion is in progress is typified by a canopy of tall eucalypts with an understorey of rainforest — but no eucalypt saplings. So why is this happening?

It is likely that the rainforest margin has, in the past, been controlled by disturbance, primarily fire. Wet sclerophyll and rainforest have very different reactions to fire. Rainforest (although it does not normally burn) cannot survive repeated fires, whereas sclerophyll plants can tolerate and even require it. In a marginal area, therefore, fires will kill young rainforest species allowing sclerophyll species to remain.

The Wet Tropics is a diverse area. While its rainforests are its most celebrated feature they are by no means the only vegetation community. Once an area has been taken over by rainforest, however, the change is irreversible because it does not burn easily. Therefore, it seems that fire is necessary, in certain circumstances, to limit rainforest in the Wet Tropics so that diversity can be maintained.



Fire and diversity

The subject of fire raises considerable controversy usually because it is seen simply as a destructive force. It is superficially difficult to distinguish between wildfire and deliberate burning but the effects are very different.

At the time of European settlement the environment had been influenced by Aboriginal burning practices. Since these have largely ceased in the Wet Tropics, some natural vegetation (outside those areas totally transformed by European farming practices) has been changing.

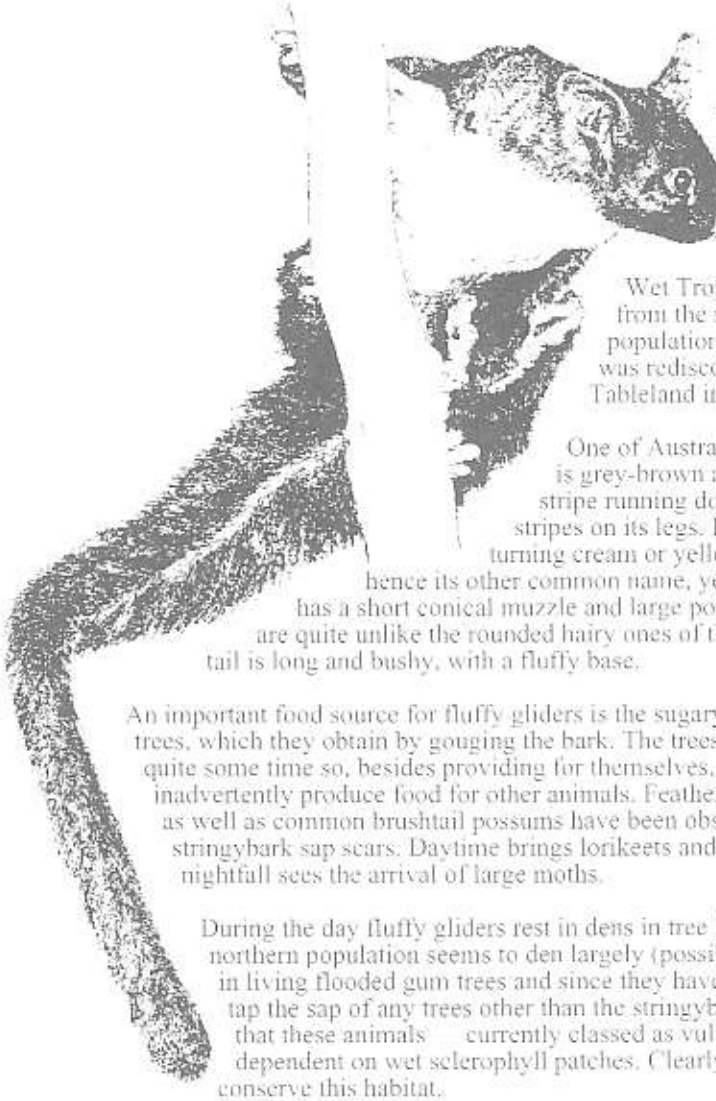
Hazard-reduction burning is carried out to minimise the impact of wildfires but managers of the Wet Tropics are faced with an important decision. Current objectives are to maintain existing habitat diversity. Should they reintroduce the fire regimes of the Aborigines to maintain existing vegetation and to recover previous environmental diversity — thus leaving options for the future open — or should they allow nature to take its course at the risk of permanently reducing diversity in the area?

This chapter presents different approaches to fire management and focuses on flora and fauna, outside the rainforest, which stand to gain from deliberate, positive use of fire.

Beyond the rainforests

Bordering on rainforest, with very similar requirements, wet sclerophyll woodland — also known as tall open forest — is characterised by trees such as flooded gum (*Eucalyptus grandis*), red stringybark (*Eucalyptus resinifera*), bloodwood (*Eucalyptus intermedia*) and turpentine (*Syncarpia gomulifera*).

Two rare mammal species in the Wet Tropics are associated with wet sclerophyll forests.



The fluffy glider

Although it had been reported from the Cairns area in the 1930s and Mt Spurgeon in 1954, the presence of the fluffy glider in the Wet Tropics, some 600km from the nearest known population, was in doubt until it was rediscovered on the Atherton Tableland in 1977.

One of Australia's largest gliders, it is grey-brown above with a dark stripe running down its back and dark stripes on its legs. Its belly is white turning cream or yellow in older animals hence its other common name, yellow-bellied glider. It has a short conical muzzle and large pointed naked ears which are quite unlike the rounded hairy ones of the greater glider. Its tail is long and bushy, with a fluffy base.

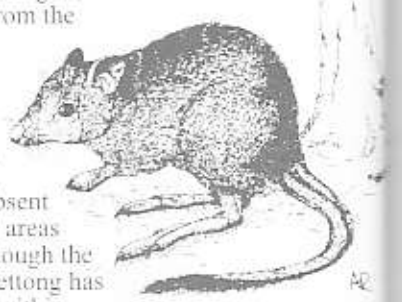
An important food source for fluffy gliders is the sugary sap of stringybark trees, which they obtain by gouging the bark. The trees continue to ooze for quite some time so, besides providing for themselves, these gliders also inadvertently produce food for other animals. Feathertail and sugar gliders as well as common brushtail possums have been observed lapping at the stringybark sap scars. Daytime brings lorikeets and honeyeaters while nightfall sees the arrival of large moths.

During the day fluffy gliders rest in dens in tree holes. Since the northern population seems to den largely (possibly even exclusively) in living flooded gum trees and since they have not been observed to tap the sap of any trees other than the stringybarks it would seem that these animals — currently classed as vulnerable — are highly dependent on wet sclerophyll patches. Clearly it is important to conserve this habitat.

The northern bettong

The northern bettong (*Bettongia tropica*) is a relative of the brush-tailed bettong which was once widespread over much of southern Australia but is now confined to a few small pockets. Both are now endangered species.

The northern bettong is a delicately built rat-kangaroo, pale grey above with cream on the belly and a short black brush on the tip of its tail. The main population in the Wet Tropics is on the Lamb Range. (It has been recorded from the Windsor Tableland and the Carbine Tableland, but is possibly absent from these areas now.) Although the northern bettong has been seen within rainforest margins and adjacent dry sclerophyll forests it tends to be found mainly in wet sclerophyll areas similar to those inhabited by the fluffy glider.

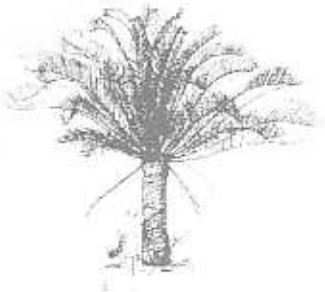


Studies on the closely related Tasmanian bettong indicate that this animal benefits from fire because it stimulates the fruiting of underground fungi, its main source of food. The best population numbers of the northern bettong are found at Lamb Range, an area which is burned every two years or so.

Living with fire

Many eucalypts possess epicormic buds which are hidden under, and protected by, the bark. After the leaves are removed by fire (or insects) the plant uses energy stored in the stem and roots to produce clumps of shoots — which give the trees a strange fuzzy look.

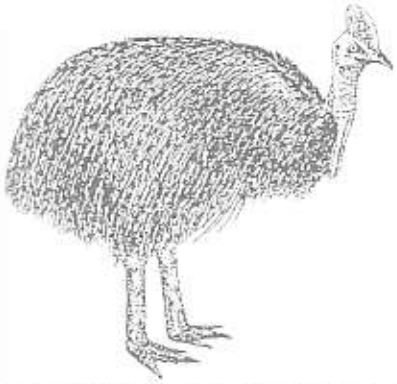
One particular skipper butterfly, *Neohesperilla senta*, lays its eggs on new grass produced after fire. The larvae can only eat young shoots — then the new adults must find more recently burned patches for further generations. The lifecycle of this butterfly clearly depends on patch burning which allows the new adults to move on as the grass becomes too tough.



Fire stimulates production of flowers and large numbers of starchy seeds in cycads. Many species can only grow where there is enough light and benefitted from Aboriginal burning. Groves, used in the past for food, can be seen at Cedar Bay and at Jourama Falls.

Fire also splits seed capsules of fire-adapted plants such as acacias, banksias and eucalypts.

Cassowary mosaics



Cape Tribulation was known by the local Aborigines as Kurangee, 'The place of many cassowaries'. Now the area supports only a few cassowaries, largely a reflection of the change in vegetation from fire-maintained sclerophyll forest to rainforest. This may seem like a contradiction the cassowary is known as a rainforest inhabitant. However, although cassowaries do spend much of their time feeding on rainforest fruits, at certain periods in the year this supply dries up. Then the birds need to move out in search of alternative food in nearby sclerophyll forests or swamplands. To preserve only rainforest is not necessarily in the interest of this endangered bird which depends on a mosaic of vegetation types.

The border between two habitats is termed the 'ecotone'. Attracting creatures from both communities, this zone often has a greater variety of animals than either of the overlapping habitats. The areas between wet sclerophyll forests and rainforests are therefore likely to be species-rich.

Fires and forests

Rainforest and sclerophyll forests have very different reactions to fire.

Sclerophyll forest burns easily because

- it is dry, at certain times of year
- the grassy understorey carries fire
- there are flammable oils in leaves and twigs
- leaves do not break down quickly and, combined with fallen bark strips and branches, provide abundant flammable fuel
- open crowns encourage updraughts

Sclerophyll forest survives fire because

- thick bark protects the trunk
- in many species swellings under the ground (lignotubers) or buds under the bark (epicormic buds) will shoot if the tree is badly damaged
- seeds may need fire for dispersal or for germination
- a nutrient-rich ash bed and sterilised soil, free of disease, fungi and seed-thieving ants, is ideal for growing seedlings

Rainforest does not burn easily because

- the high mineral and moisture composition and low oil content of the leaves makes them relatively inflammable
- leaves break down quickly so there is not much dry leaf litter for fuel
- lack of light on the forest floor suppresses grasses which would carry fire

Fires in rainforest are usually a result of severe drought combined with disturbance such as cyclones or logging. Fire may also burn the margins of rainforests on steep slopes with adjacent grassland.

Rainforest suffers from fire because

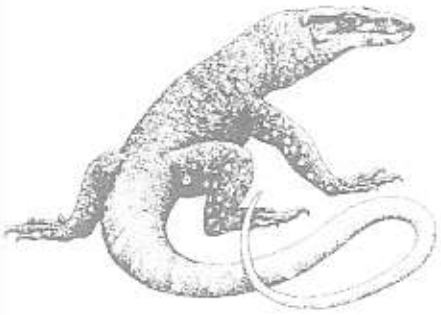
- thin bark of the trees offers no protection
- fire in the leaf litter destroys roots close to the surface

*However, some rainforest species, such as the narrow-leaved lilly pilly (*Acmena smithii*) will coppice from the base as eucalypts do and may be able to survive some fire.*

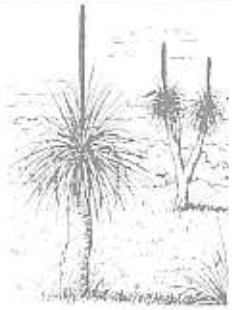
Wet sclerophyll forest and fire

The relationship between fire and wet sclerophyll is not yet fully understood. There seems to be a paradox involved. Studies of the flooded gum (*Eucalyptus grandis*) show that fire is needed to establish new generations. It clears away the undergrowth to provide the correct light conditions and produces an ash bed which promotes germination. On the other hand the young trees do not have barks thick enough to withstand fire. Flooded gums also lack lignotubers so cannot sprout from the base after they have been burnt.

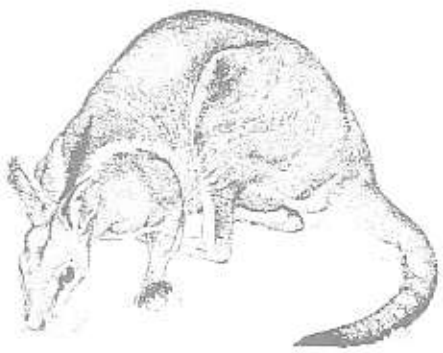
It would seem that while fire is necessary for the production of new generations of this type of forest, frequent fires would destroy the saplings. Intervals of 40 years, however, may allow a rainforest understorey to establish to the extent that the forest will not burn. Natural drought cycles of 20 years or so may create conditions for the rainforest to be burnt back but research is required to determine the necessary regime.



Fire brings times of plenty for many birds of prey and scavenging animals such as this monitor lizard which feed on animals burnt or exposed by fires.



Grass trees (*Xanthorrhoea*) flower prolifically after being burnt, providing, in turn, nectar for birds and insects. Other plants, including certain ground orchids also flower after fire. This is probably because extra nutrients are provided by the ash but may also enhance the chances of pollination with a large show of visible flowers. Of course if seeds are produced quickly they will drop on the nutrient-rich ash bed.



Many animals, notably kangaroos and wallabies, enjoy the fresh shoots of grass (known as 'pick') which spring up after fire.

Managing fire

Present burning practices

Prescribed burning

This refers to fire deliberately used by a land manager to achieve a specified goal. There are two main aims. The goal of **hazard reduction** fires is to pre-empt wildfires by burning off fuel loads (such as dead plant matter) under controlled conditions at the most appropriate times for the vegetation involved. Cool, calm days when soils and fuels are moist create slow-moving fires with low flames. These cause little damage to trees and give animals a chance to escape. The goal of **ecological** fires is to manipulate the vegetation structure. These may be of higher intensity to achieve maximum effect on unwanted plants (such as rainforest in wet sclerophyll), debris, etc.

Aboriginal burning practices

The first fire managers in Australia were the Aborigines. Early accounts refer frequently to their skillful use and control of burning. They used it in numerous ways. Fire was an early form of stock management, used to promote new growth which would attract animals for hunting or to drive game into an ambush. Undergrowth was burnt to provide easier passage — in some areas (notably Iron Range) corridors of sclerophyll forest mark old Aboriginal tracks through the rainforest. Smaller fires were used to fell dead trees for firewood by burning their bases, to flush out small mammals and reptiles from undergrowth or holes and to clear areas before digging for edible roots. Small controlled fires were set early in the dry season to reduce the likelihood of later life-threatening wildfires and sometimes fire breaks were created to protect the rainforest or sacred sites.

Employing a sound appreciation of its behaviour, the Aborigines skillfully manipulated fire by timing it according to vegetation and weather conditions and by using their knowledge of landscape features which would act as natural breaks. The early inhabitants of Australia may not have had ploughs but in their hands fire was a useful and appropriate tool. 'Firestick farming' enabled them to lead what has been termed an 'affluent' hunter gatherers' lifestyle.

Three fire sites

Different sites have different requirements. Below are three examples in the Cairns area.

Cairns Hillslopes (fire exclusion)

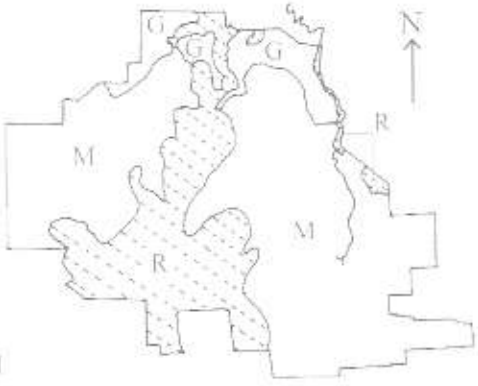
The rainforests of these hillslopes have suffered badly since European settlement. In the past fires frequently escaped from the cane fields or from along the Kuranda railway line when vegetation was burnt off to protect the tracks. Although rainforest does not burn easily it cannot withstand repeated high intensity fires. Increasingly large tongues of fire-induced grassland, composed mainly of tall, highly-inflammable non-native species such as guinea and molasses grass, carried fires progressively further up the hillsides into parts of the Barron Gorge National Park.

The hillslopes of Cairns are a top tourist asset so local government is keen to promote revegetation. In the Redlynch area a 3-5m wide bulldozed buffer strip has been constructed 20-200m uphill from and parallel to the railway line and the area between is burnt annually to provide a fuel-free strip. Then, 10m above this firebreak, a dense strip of native trees has been planted. For several years community volunteers took part in annual planting days. Fast-growing pioneer species were used and the result is a dense strip of vegetation which not only resists the spread of fire but also shades out the grass. It also attracts birds and other animals which do their bit by spreading the seeds to other degraded areas. These plantings have become substantially 'fire-safe' within six years and the scheme has been successful in its aim of excluding fire from those hillslopes.

Eubenangee Swamp (ecological fires)

Apart from reducing fuel loads, fire in melaleuca swamps (M) prevents invasion by non-native plants such as pond apple bush (*Annona glabra*). These areas are burnt every six to nine years but it has to be done while about 5cm of surface water remains. Fire in dry times could result in a very destructive burning in the peat layer. Two areas are burnt in different years.

The grasslands (G) begin to decline after



about three years without fire. Moderate to high intensity fires stimulate the revival of a number of species that have 'disappeared'. Ideally these areas are burnt every three years but at times when adjacent areas are still wet so the fire will not spread. Areas are burnt in different years.

Rainforest (R) is not burnt at all but protected from fire.

Captain Cook Highway north of Cairns (hazard-reduction fires)

Severe wildfires along the grassy coastal hills are almost an annual event due largely to arsonists. On the steep slopes these fires have tended to be of high intensity, difficult to control and a threat to buildings as well as a pocket of rare lowland rainforest. A plan is being implemented to control the situation with a series of hazard reduction fires. These are lit soon after the wet season when they can be controlled using natural barriers such as rocky gullies or greener vegetation.

The area has been divided up into zones to be burnt at different times. The aim is to produce a mosaic of burnt and unburnt areas which reduces the chances of subsequent wildfires sweeping through the whole area.

Since 1991, a community group, Treeforce, has been hard at work planting trees on the hillslopes above Aeroglen. A small forest now grows where the first plantings took place and the establishment of an irrigation system*, along with fire breaks, is helping more recently planted areas to survive the wildfire season.

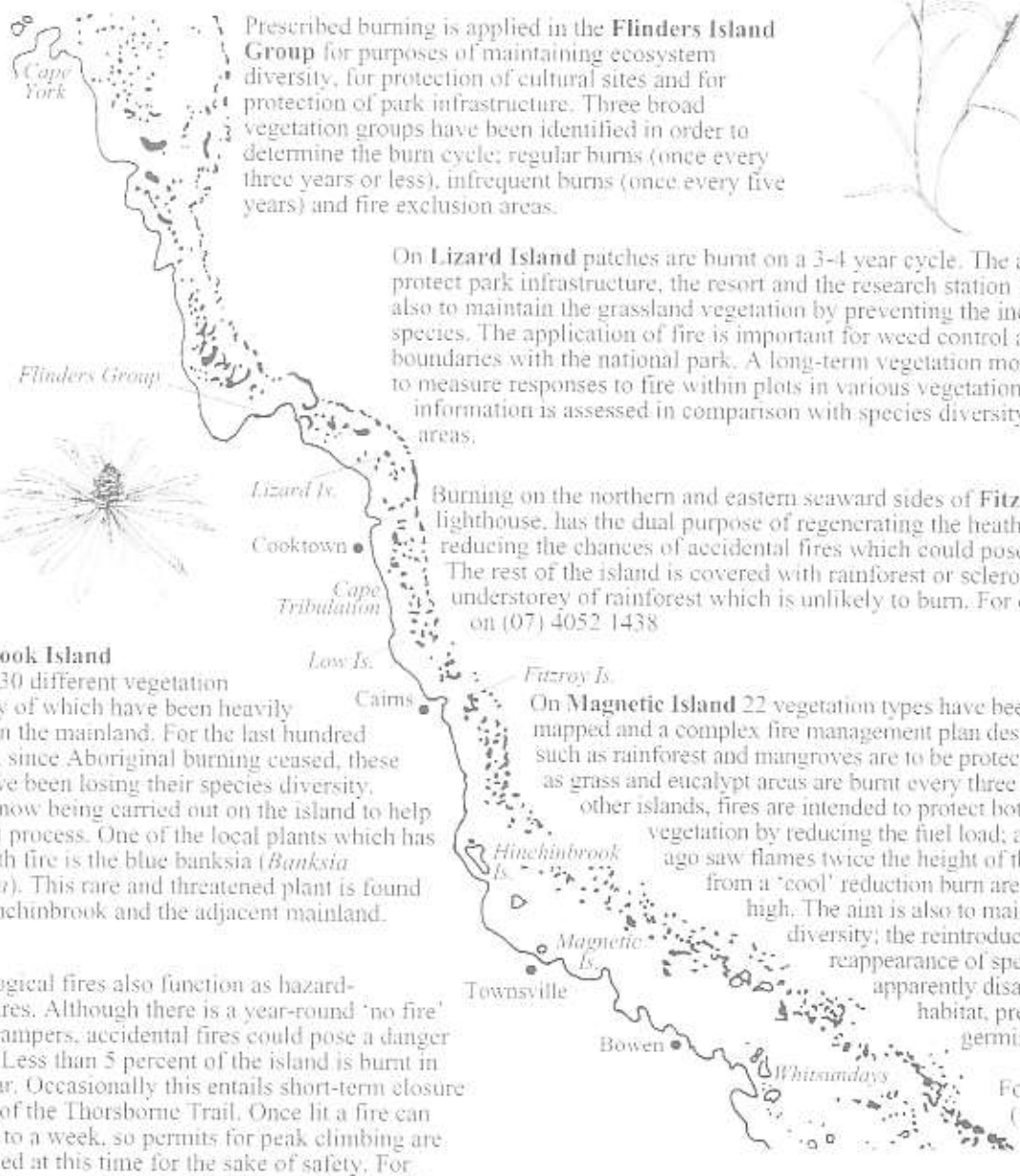
For more information on Treeforce, call (07) 4056 5106 or (07) 4058 1155.

** Funded by DoE, Cairns City Council, Reef Casino Benefit Trust Fund and Port Authority.*

Fire on islands

Prescribed burning is carried out on many of the national park islands.

Fire is one method of controlling Cenchrus echinatus *a central American weed with unpleasant burrs which has travelled to Lizard Island.*



Prescribed burning is applied in the **Flinders Island Group** for purposes of maintaining ecosystem diversity, for protection of cultural sites and for protection of park infrastructure. Three broad vegetation groups have been identified in order to determine the burn cycle: regular burns (once every three years or less), infrequent burns (once every five years) and fire exclusion areas.

On **Lizard Island** patches are burnt on a 3-4 year cycle. The aim of this is to protect park infrastructure, the resort and the research station from wildfire and also to maintain the grassland vegetation by preventing the incursion of woody species. The application of fire is important for weed control around the lease boundaries with the national park. A long-term vegetation monitoring study aims to measure responses to fire within plots in various vegetation communities. This information is assessed in comparison with species diversity in fire exclusion areas.

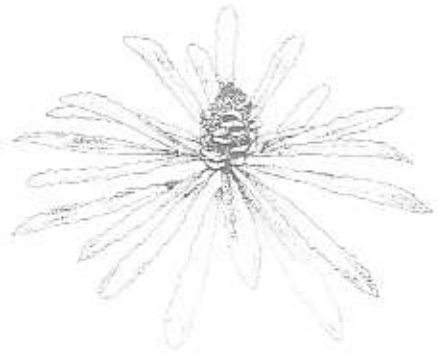
Burning on the northern and eastern seaward sides of **Fitzroy Island**, around the lighthouse, has the dual purpose of regenerating the heath and woodland and reducing the chances of accidental fires which could pose a danger to walkers. The rest of the island is covered with rainforest or sclerophyll forest with an understorey of rainforest which is unlikely to burn. For details call the ranger on (07) 4052 1438.

Hinchinbrook Island is home to 30 different vegetation types, many of which have been heavily disturbed on the mainland. For the last hundred years or so, since Aboriginal burning ceased, these habitats have been losing their species diversity. Burning is now being carried out on the island to help reverse that process. One of the local plants which has evolved with fire is the blue banksia (*Banksia plagiocarpa*). This rare and threatened plant is found only on Hinchinbrook and the adjacent mainland.

These ecological fires also function as hazard-reduction fires. Although there is a year-round 'no fire' policy for campers, accidental fires could pose a danger to walkers. Less than 5 percent of the island is burnt in any one year. Occasionally this entails short-term closure of sections of the Thorsborne Trail. Once lit a fire can burn for up to a week, so permits for peak climbing are also restricted at this time for the sake of safety. For details call the ranger in charge at Dungeness on (07) 4777 8356.

On **Magnetic Island** 22 vegetation types have been identified and mapped and a complex fire management plan designed. Some types, such as rainforest and mangroves are to be protected while others such as grass and eucalypt areas are burnt every three to five years. As on other islands, fires are intended to protect both property and vegetation by reducing the fuel load; a wildfire some years ago saw flames twice the height of the trees whereas flames from a 'cool' reduction burn are only about one metre high. The aim is also to maintain biological diversity; the reintroduction of fire has seen the reappearance of species which had apparently disappeared from the habitat, presumably through the germination of buried seeds.

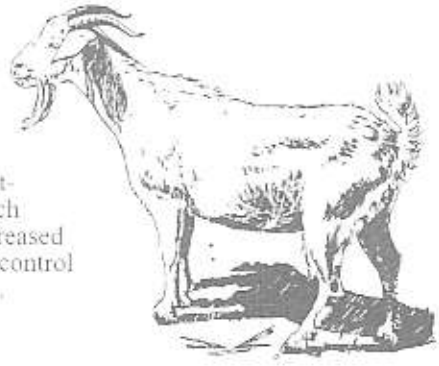
For details call (07) 4778 5378.



The blue banksia is benefiting from burning on Hinchinbrook Island.

In the **Whitsundays** fire is again used to protect resorts and walking trails from accidental wildfires and to maintain biological diversity, particularly of grassland containing the last remnants of native species. It has been discovered that hot and cool fires encourage different grass species.

Fire has also been used in the elimination of populations of wild goats on Lindeman and South Molle Islands. The animals were removed easily after being attracted to fresh post-fire vegetation. Growth of lantana which the goats had been feeding on then increased sharply and was in turn brought under control by fire. For details call (07) 4946 7022.



Facts and stats

on fire

Fire is a chemical reaction during which hydrocarbon fuel combines with oxygen to form carbon dioxide (Co2) and water vapour. Complex organic substances (plants) are reduced to simpler inorganic compounds such as ash and charcoal (carbon). Fire releases, in the form of heat, large amounts of energy, which have been stored through photosynthesis. In a dry forest each kilo of burning fuel releases about 18 000 kilojoules of energy. A 100 watt electric light bulb takes 50 hours to use this much energy.

Burning of sugar cane fields began in the 1930s to cut down on the incidence of the potentially fatal Weil's disease. The organism causing this is present in rat's urine and was picked up by cane cutters during harvesting. The first mechanical harvesters, introduced in the 1960s, were designed to deal with burnt cane. A reduction of world sugar prices in the early 1980s encouraged farmers to adopt the newly developed and more economical green harvesting machinery.

It is now thought that smoke, rather than heat, is responsible for germination in some Australian plant seeds. Researchers subjected the seeds of 94 Western Australian plants which normally have low germination rates to cold smoke and to water through which smoke had been passed. Germination rates increased significantly. It is thought that ammonia in the smoke may be important.

Control over the lighting of fires comes under the Queensland Fire Service Act of 1990. The lighting of a fire bigger than two metres in any direction requires a permit from you local Fire Warden.

Rainforest has a canopy which is over 70 percent closed (that is, if you look up, 70-100 percent of the sky is obscured by branches). Wet sclerophyll forest is 30-70 percent closed.

Of the 400 or so eucalypt species of Australia only 12-15 lack lignotubers which enable the trees to sprout from the ground (coppice) after fire or other destruction of the upper part.

Bookshelf

Fire and the Australian Biota
A.M. Gill, R.H. Groves and I.R. Noble (eds)
Australian Academy of Science (1981)

A comprehensive look at the subject, this book is divided up into sections on *Fire History, Physical Phenomenon of Fire, Responses of the Australian Biota, Responses of Selected Ecosystems* and *The Role of Fire in Ecosystem Management.* Since the book deals with the whole of Australia not all of the information is relevant to the Wet Tropics but there is plenty of interest.

Fire Management
Brochure produced by Department of Environment
Available at DoE offices

One of the few publications relevant to the Far North this brochure looks at the historical and ecological role of fire as well as fire management in national parks.

Fire Management Strategies
Brochure produced by the Wet Tropics Management Authority and the Rural Fire Division of the Queensland Fire Service
Available at DoE offices

This looks at fire management in different vegetation types in the World Heritage Area and the relevant legislation.

Bush Regeneration
Recovering Australian Landscapes
Robin A. Buchanan
TAFE Student Learning Publications (1991)

Although dealing with general techniques and strategies for recovering degraded landscapes, this attractive and readable book necessarily considers the role of fire in the equation. Types of fires are analysed at the end of Chapter 5 (*Regeneration Techniques*) and Chapter 6, *Regeneration of Plant Communities*, considers the effect of fire on everything from mangrove swamps and sand-dunes to rainforests, including a section on wet sclerophyll forests. Unfortunately much of the information is more relevant to southern parts of Australian then to northern regions.

Trees and Natural Resources December 1992
Fire: An Ecological Catalyst
Kevin Tolhurst

Nature Australia Vol. 25 No. 7 Summer 1996/97 page10
Smoking or non-smoking?

A short article describing research which showed that it is smoke, rather than heat, which appears to stimulates germination in some Australian plants.

Australian Rainforests
Paul Adam
Oxford Monographs on Biogeography No. 6
Oxford University Press (1992)

While of general interest to readers concerned with rainforest, Chapter 4 on *Rainforest Boundaries and the Problem of Mixed Forests* and Chapter 5 on *Regeneration and Response to Disturbance* take fire into account.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
fire	Feuer	kaji	火事
accidental	unbeabsichtigt	goo zen no	偶然の
controlled	kontrolliert	shihai sare ta	支配された
burn	verbrennen	moyasu	燃やす
rainforest	Regenwald	nettai u rin	熱帯雨林
invade	eindringen	osou	襲う
grass	Gras	kusa	草
adapted	angepaßt	tekiou shita	適応した
diversity	Verschiedenheit	tashu tayo sei	多種多様性
regeneration	Regeneration	sai sei	再生

Caring for country

Past to present, a culture lives on

When Captain Cook sailed up the coast in 1770, the rainforests of north Queensland were home to particularly dense populations of Aboriginal people — a density directly related to the abundance of available food.

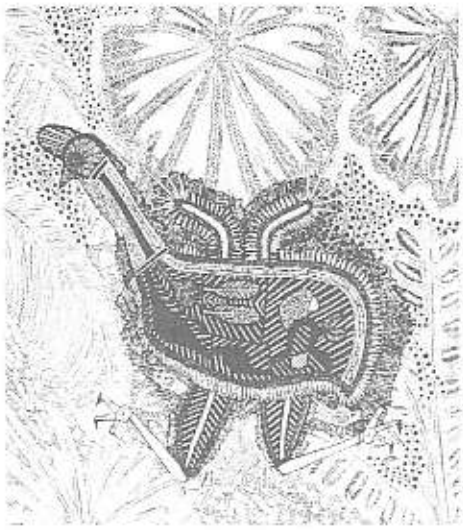
Clan or tribal areas were relatively small. Movements of people within them were never random but linked to an intimate knowledge of what food was available where, when and in what quantities. When food was scarce small groups scattered and when it was abundant they gathered in large groups.

Just as the environment in which they lived was diverse, so were the people who lived in it; the rainforest Aboriginal culture was by no means a homogenous one. The numerous languages used differed as much as, for example, French and German, and served to identify members of different groups. Social rules varied as did plant uses and implements.

Aboriginal culture was not an unchanging one, frozen in time. Even before the arrival of Europeans, ideas were adopted from outside; for example, the outrigger canoe introduced from Melanesia. In their turn, European materials were quickly utilised — telegraph wire cut down for spear heads, for example. The arrival of Europeans, of course, had more profound effects. The removal of people from their tribal areas and the breaking up of families was devastating for Aboriginal culture.

Few Aboriginal people today move according to food sources or build shelters in the forest, but gather their main supplies in the same supermarkets as Australians of more recent origin. However, the old knowledge is far from lost. The concept of 'caring for country' persists; significant sites are looked after and stories and skills passed on. Hunting, fishing and the gathering and processing of wild food form vital links with the past still exercised by a large number of indigenous people. But adaptation is a feature of all human societies. Metal graters are used on black beans which formerly would have been ground between two stones. Introduced feral animals such as pigs are hunted. Canvas and acrylic paints are used instead of bark and red ochre. Traditional dancing is being revived — often with a microphone placed by the didgeridoo so a wider audience can be reached.

Aboriginal culture is often described in the past tense as if it is dead. However, while 200 years of European influence has undoubtedly changed it radically, it has proved to have tremendous staying power. The link with the past is very strong and should be celebrated.



Still caring for country

'Country' is the term given by Aboriginal or Torres Strait Islander people to the clan or tribal area from which they originate. It is not only the home from which they harvest their food and other resources but it also sustains their spirituality. Non-Aboriginal people have only relatively recently begun to appreciate the strength of the bond between indigenous people and their country; the importance of recognising and re-establishing that bond is a fundamental principle behind recent legislation. It has also led to the increasing participation by indigenous people in the management of protected areas such as national parks — 'caring for country'.

Cultural tourism is a growing industry in Australia. Visual arts and crafts, performing arts, cultural centres and guided tours all involve increasing numbers of indigenous Australians as producers, owners, managers and employees. It is appropriate for Aboriginal rangers and guides to not only participate in caring for their country but also help explain it to outsiders. This is not only a good source of employment in remote areas, leading to economic self-sufficiency, but helps to promote interracial understanding — an important step towards reconciliation.

Yarrabah artist, Djangan, combines traditional and contemporary designs. This painting was created with acrylic and natural dyes on fabric.

Djangan is a member of the Bama Ngappi Ngappi Corporation based in Yarrabah and specialising in art and artifacts in this style. They can be contacted by phone or fax on (07) 4056 9145 .

Using the plants

Courtesy Queensland Museum

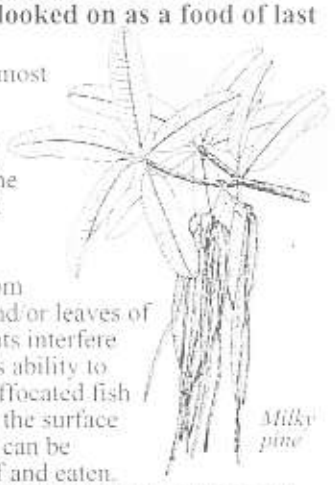
This information about rainforest Aboriginal plant use was gleaned from a number of sources in the Wet Tropics and would not necessarily be applicable to all parts. As pointed out earlier, Aboriginal societies varied considerably within the area and so too did their uses of plants. For example, black bean, while relished in the Tully area, was looked on as a food of last resort around the Bloomfield River.

A particular feature of Aboriginal rainforest food use is the unusually large number of **toxic plants** eaten as staples. Some of these only need to be heated or beaten to become edible but about 15 species also need to be washed with running water to remove the poisons. Two of the most important of these are the black bean (a common rainforest tree) and the cycad (found more in open woodland). The poisons in both these foods are extremely strong, causing vomiting and/or diarrhoea and, in the case of the cycad, containing toxins which can cause cancer.

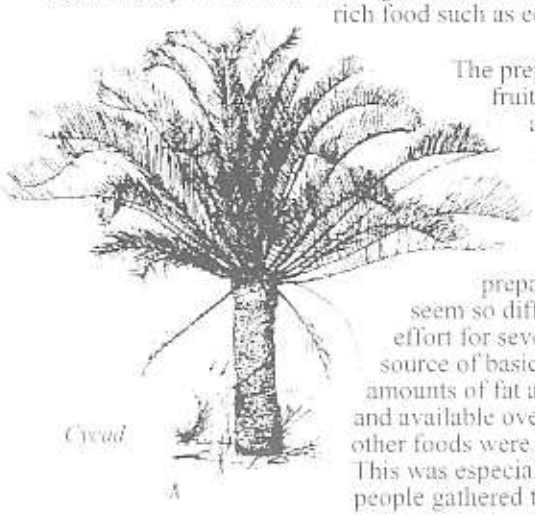
Black bean trees crop in winter but nuts can be gathered at almost any time of year. Traditionally the seeds were steamed, with wet candlenut leaves, in a ground oven for a day. Nowadays the beans are generally boiled over a large fire. The beans, now black, are sliced finely — traditionally with a sharp snail shell or, these days, with a knife or metal grater. The next step is to leach away the toxins with running water. A basket full of the black bean fragments is placed in a river in gently flowing water, secured so that turtles or eels cannot tip it over and, nowadays, placed where pigs will not eat the food. After three to five days, when it is suitably soft, the black bean is ready to be eaten. Although bland it can be eaten with rich food such as eels.

Black bean

One of the most intriguing traditional methods of **fishing** is the use of plant poisons. Chemicals released from bark, sap and/or leaves of certain plants interfere with a fish's ability to breathe. Suffocated fish then rise to the surface where they can be scooped off and eaten. Over thirty different plants can be used for this, including cocky apple, milky pine, beach almond and certain vines — matchbox bean and *Derris* species.



Milky pine



Cycad

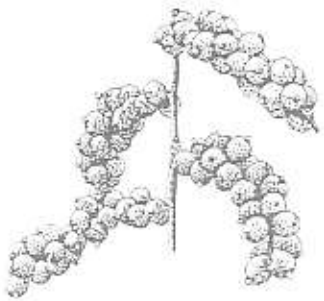
The preparation of cycads is similar. The fruits, after the roasting or boiling stage, are cracked open and the kernels removed. It is these which are ground and leached.

Why bother with this long process? Well, if we compare it to the preparation of bread from wheat it doesn't seem so difficult. Toxic foods were worth the effort for several reasons. They tended to be a good source of basic carbohydrates and contain moderate amounts of fat and protein. They were often abundant and available over extended periods, perhaps when other foods were scarce, and they could be stored easily. This was especially important when large numbers of people gathered together.

BEWARE

There are many poisonous plants in the rainforest. It is extremely foolish to sample wild food unless you are *completely certain* of what you are eating. Even scientists with an extensive knowledge of bush tucker have ended up in hospital. It is also extremely irresponsible to invite tourists to sample bush 'foods' — in at least one case a whole party has fallen very ill as a result of this. To avoid mistakes err on the side of caution — look but don't taste.

Of course many foods are not poisonous and can be eaten without preparation. Numerous fruits such as *Syzygium* and lawyer cane berries are eaten raw. The soft heart of most palms is a tasty type of 'cabbage' while the young fronds of tree ferns can be eaten raw or cooked. Roots, shoots, nuts, seeds, leaves, stems — the forest has abundant food for those who know what can be eaten!



Lawyer cane berries

Cunjevoi

Numerous plants have **medicinal uses**. For example, sap from heated leaves of the cordyline lily can be applied to cuts while the large leaves of the cunjevoi (another toxic food plant) can be pounded and applied to insect and snake bites and to stingray stings. The sap of milky pine is said to sooth the pain of stings from the stinging tree.

Plants of many uses

Pandanus plants provide leaves used extensively for thatching, bags, baskets, mats and so on. The 'cabbage heart' can be eaten as can the fruit, although it is called 'old persons' food' because the picking away of fibres requires so much patience. A white liquid from crushed stem and roots is applied to wounds or used as a mouthwash for sore throats and toothache.

In order to understand the plants of a particular area it is best to be guided by a local Aboriginal inhabitant. Not only is this important for correct plant identification (especially if bush tucker is to be sampled) but avoids the potential problem of infringing 'cultural and intellectual copyright'. Access to knowledge is strictly controlled within Aboriginal societies. A local guide will know what can, and what cannot, be communicated to outsiders. As interest in indigenous cultures grows, the inclusion of a local guide on tours is often welcomed by tourists who appreciate the chance for genuine interaction.

A range of **tools** can be made from ingenious use of rainforest plants. Firesticks, an essential item, come in two parts. For the upper stick a soft wood such as the flowering stem of the grass tree or a fine branch of macaranga or native guava is used. The base is of less soft wood, milky pine being a favourite. The upper stick is slotted into a notch in the base and twirled rapidly between the palms of the hand. The resulting spark is caught on a soft material such as coconut fibre and fanned until a flame appears.

Grass tree

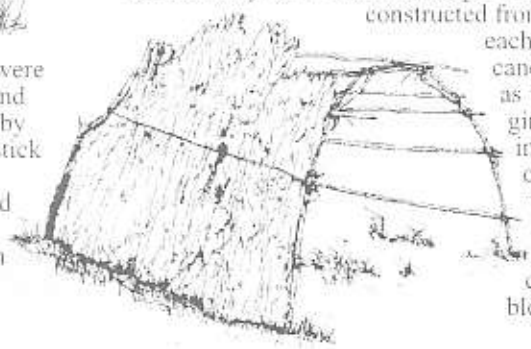
The buttresses of rainforest trees were often cut, in the past, for shields and boomerangs. Spears can be made by cutting the end of a straight long stick into four and inserting stones or sand for weight. The pointed wood or bone end can then be glued on with the softened sap of trees such as the euodia and tied on with macaranga fibre.

Plants and animals can provide useful **seasonal cues**. Particular animal calls or developments among 'calendar plants' indicate the time to hunt or collect certain things. When the tail feathers of the willy wagtail turn white, cycads, on coastal hills, are ripe so groups used to move down from the Tablelands on this cue. When the black locust first sang they knew it was time to go back to the Tablelands to harvest black pine nuts. A rush grass flowers when it is time to collect scrub fowl eggs while other plants signal the best time for building up fish traps. This is very logical: fish are easier to catch in the dry season when food is scarce than later on in the year when fruit falling into the rivers provides them with abundant alternatives.

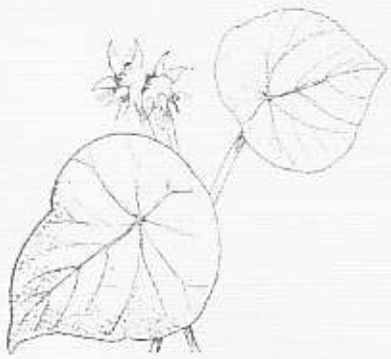
Native yam

While, traditionally, men did most of the hunting of larger animals like wallabies, possums and snakes, the women and children collected the '**reliable food**' such as plants, eggs, witchetty grubs, honey and smaller animals. While 'farming' is generally not seen as part of a hunting and gathering culture, some plants can be manipulated to produce food. When yams are gathered, part of the plant is replanted to grow again. Ring-barked candlenut trees encourage beetles to lay eggs — which hatch into tasty grubs.

Shelters built in the past ranged from semi-permanent shelters designed to give protection through the wet season to basic shade or overnight shelters. They are still occasionally built. Materials depend on availability. The basic framework is usually constructed from saplings stuck in the ground and bent towards each other to be tied together with vines or lawyer cane in a series of arches. A variety of materials such as fan palm fronds, blady grass, lawyer cane and ginger leaves can be used for thatching. An important waterproof material is paperbark, sheets of which are cut from the trunks — traditionally with a stone axe, but now with metal tools. Starting from the bottom, sections of bark are built up, overlapping so rain will run off. Lawyer cane over the top prevents the bark from being blown off.



Gingers have long leaves which are commonly used to wrap fish and meat cooking in a ground oven, as thatching on shelters or to make spouts to direct water through baskets during the leaching of toxic foods. The rhizome tips and berries are edible, the latter making a good bait for bush turkeys.



Macaranga, a very common tree, has soft timber which provides light spears for fishing and fire sticks. The bark fibres can be used for string and the large leaves for plates and cups and for wrapping food, such as snake segments, when being cooked in the fire.

Lawyer cane has edible berries and sections of cane can be roasted and eaten. The sap is drunk to relieve colds and the young tips chewed and swallowed to stop dysentery while water can be obtained by cutting and draining the cane. The strong flexible cane itself is used to make baskets, traps, shelters, handles and for binding axe heads and so on. The infamous thorns can be made into fish hooks and the seeds can be used as beads.

Community Rangers – caring for their country

In 1987 it was recognised that there was a need in Aboriginal and Torres Strait Island communities for land, sea and resource management training. As a result, the Cairns College of TAFE was approached by the Aboriginal Co-ordinating Council to establish a suite of courses to address their needs.

The first intake was in 1989, with students enrolling in CNJ18 Certificate in Natural and Cultural Management. This course can be completed in one year of part-time study.

CNJ19 (Advanced Certificate) can be completed in the second year, and CNJ20 (Associate Diploma) normally takes a further two years.

Practical skills taught include such things as map reading, site surveys, animal and plant field skills, visitor facility management, first aid and office management. An ecological component includes vegetation management and feral animal control as well as traditional knowledge.

Marine studies include fisheries management while tourism and interpretation is aimed at project related tourism.

Archaeological and anthropological knowledge and techniques are gained in class as well as on sites in the field.

Students from 17 communities in Cape York participated in the initial program. The students were employed as Community Rangers by Community Councils. These councils and elder groups supported rangers with Community Development Employment Program positions and allocated roles and responsibilities. The Community Services Act provided a legislative framework for rangers as authorised officers of the Act.

These roles vary from place to place but can include recording and managing sites of significance, burial places, story sites, recording cultural information from elders and helping teach young people about environment and culture.

Community Rangers can administer campsites and give guided tours that introduce their culture to tourists. They can control feral animals and weeds or soil erosion or work with fisheries management.

While much of the funding comes from the Community Development Employment Program some Rangers are employed through various bodies.

DoE has employed Community Rangers to carry out track and other work while GBRMPA has utilized the services of Rangers along the coast to carry out work such as water quality sampling and turtle and dugong monitoring.

Students now come from communities all over Queensland.

The program originally employed trainer/co-ordinators who lived on communities to deliver training to clusters of students. Reduced levels of funding, constraining work place agreements, and high costs have resulted in the adoption of flexible training practices to meet the student demand.

Part-time students currently attend residentials in various locations run by teachers. Students learn theory, then return home to complete practical assignments. Different support mechanisms are being introduced, including the Internet and video conferencing.

The ideal place to train people doing the suit of courses is at their own community. Here, Council and community co-operation is essential.

To meet the changing demands of the communities on the mainland and within the Torres Strait, new courses are developed as required and students find that they have a much wider choice of electives which more closely mirror the needs of their areas. The courses are nationally credited, so that the qualifications gained will be recognised anywhere in Australia.

People requiring information or wishing to enrol should contact:

The Program Manager
Indigenous Environment Program
Tropical North Queensland Institute of TAFE, PMB 1, Cairns 4870
Ph: (07) 4042 2588
Fax: (07) 4042 2607

Entry is restricted to Indigenous Australians.

Further details from the Aboriginal and Torres Strait Islander Curriculum Consortium, Tropical North Queensland Institute of TAFE.
Ph: (07) 4042 2476,
Fax: (07) 4042 2604

Contributed by Norman Atkinson, Community Ranger Training Program

Land Rights — a brief guide to the legislation

The **Aboriginal Land Act** 1991, a Queensland State act, provides for the granting of land as Aboriginal land. It provides several mechanisms for Aboriginal people to claim land on the grounds of traditional affiliation, historical association or economic or cultural viability. These claims are restricted to transferrable land which has been gazetted by government as available for claim; so far 12 national parks in Cape York and two in other parts of Queensland have been gazetted. Once successfully claimed, these parks must be leased back to the government and jointly managed as national parks.

The **Native Title Act** is a Commonwealth Act and is complemented by Queensland legislation. It followed the High Court judgement in the Mabo case which found that Native Title was extant on Murray Island. Eddie Mabo was a member of the Meriam people of Murray Island in Torres Strait. For 10 years he and three other Murray Islanders claimed in the courts that Native Title had not been extinguished when the British assumed sovereignty. In June 1992 the High Court upheld that Native Title had existed and that the doctrine of *terra nullius* (meaning 'land belonging to no one') was not valid. The Meriam people were, therefore, entitled to 'possession, occupation, use and enjoyment of Murray Island'.

The Native Title Act, which came into effect on January 1st 1994, was the legislative follow-up to the Mabo judgement. Apart from its practical effects it was of tremendous symbolic importance, confirming the status of Aboriginal and Torres Strait Islander people's Native Title. Where the Aboriginal Land Act was designed to give back land to indigenous people as an act of goodwill, the Native Title Act recognised their pre-existing rights. It also meant that any unalienated land, not just that specifically gazetted by the government, could be claimed. However, the Native Title Act validates all pre-existing land grants by governments. In many cases, such as freehold land, Native Title is considered to have been 'extinguished'.

Native Title and the High Court Wik decision

When the Native Title Act 1993 was being developed, there was a generally accepted legal opinion that the valid granting of a pastoral lease would have extinguished Native Title. However, although this view was generally accepted, there was also the possibility that this view could be successfully challenged in the courts. Consequently the Native Title Act 1993 was drafted in a way which allowed for the possibility that pastoral leases do not necessarily extinguish Native Title.

In December 1996 the High Court found that the valid granting of a pastoral lease does not necessarily extinguish Native Title. However, where the interests of pastoralists and the interests of the Native Title holders are in conflict, the rights and interests of pastoralists prevail.

The High Court decision made clear that it was not the intention of the Colonial Governments, or indeed the subsequent State Governments, to make Aboriginal people trespassers on pastoral leases after the lease was granted. Instead, it was always the intention of both the instrument of the lease, and the legislative head of power (the various Land Acts) that the vast range lands across northern Australia would have a different form of tenure to land found in more heavily settled parts of the nation.

The **Nature Conservation Act** provides, among other things, for a system to manage national parks including those successfully claimed under the Aboriginal Land Act; Aboriginal people only get *title* when a lease and management plan for that park have been accepted by the Queensland Government. The Nature Conservation Act also provides for the recognition of Aboriginal traditional practices, such as traditional use of flora and fauna, where permitted by an Aboriginal traditional authority.

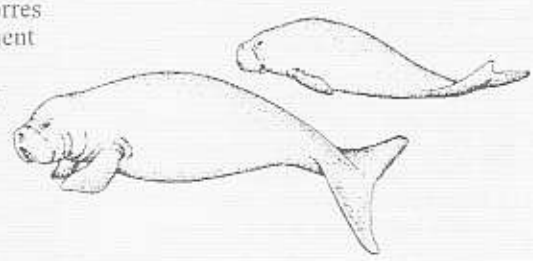
Originally the Mabo claim included the surrounding reefs and waters because in Aboriginal and Torres Strait Islander societies there is no tenure distinction between land and sea. The boundaries of traditional clan countries extend into and include areas of sea which may contain sites of significance as well as traditional resources. However, the European-based Australian attitude is that, while land can be privately owned, there is common access to the sea. Several native title claims, which include areas of sea, are currently being mediated by the National Native Title Tribunal.

Rights and protection

There is much confusion over the issues of indigenous rights and the protection of the environment. The issue, however, can be viewed as one of management. When the future of a protected species is in question the reasons for its decline may be varied and complex. The solution is for all parties concerned, including the appropriate indigenous people, to develop management plans which achieve the recovery of a species while also recognising the traditional rights of Aboriginal people. We have perhaps been slow to recognise the advantages of combining traditional knowledge with contemporary management — but this is changing.

For example there has been growing involvement of Aboriginal and Torres Strait Islander people in management of turtle and dugong populations. While wishing to continue to hunt these animals, they share a concern with conservationists for the species' survival. With indigenous people involved in research projects, data gathering, allocation of traditional hunting permits and development of management plans, decisions on sustainable use can be made in partnership.

Fishing, for most Australians, is a perfectly acceptable activity seen not only as a means of obtaining food but as a form of relaxation, linking people with the natural surroundings, and as a sport, a tradition, a communal activity, a means of expressing basic instincts... the list goes on. For indigenous people the hunting of dugongs and turtles also has an important social function and traditional rules govern how the food is divided and eaten by kin groups. Just as Christmas is a time for turkey so these marine animals are important food for indigenous communities.



Facts and stats

on Aboriginal traditions

A century before European contact, north of the 16th parallel there were about 45 distinct Aboriginal languages with several hundred dialects. In the Wet Tropics there are two main language groups: Jirrbal south of Innisfail, Yidinji, including Kuku Yalanji and Djabugay, to the north. Each has different grammatical structures and many dialects.

An intriguing feature of Jirrbal is the use of four genders. For example, French words are divided into two genders, masculine and feminine. In Jirrbal there are masculine, feminine, neuter and edible plant genders; edible plants being identified by having the word *balam* in the name.

Black bean is known as *mirrayn* in the Jirrbal language, *junggurra* in Yindinji and *baway* in Kuku Yalanji.

Aboriginal populations in north Queensland were among the densest in Australia. An estimated two square kilometres were required to support one person compared with up to 100 square kilometres per person in the deserts of Western Australia.

Whereas 'Koori' is the term which Aboriginal people use when referring to themselves in New South Wales and Victoria, the term 'Murri' is commonly used in Queensland. 'Bama' is used particularly in the rainforest region west and north of Cairns.

Termites can be used to catch fish. The mounds are broken open and the termites thrown into the water as bait. Long narrow baskets made from lawyer cane are placed in rivers to catch eels. The eel swims in — but being unable to swim backwards cannot retreat from the basket's confines.

Stone fish traps are a feature on Hinchinbrook Island and other parts of the Queensland coast. Built by hand, semi-circular rock walls formed weirs into which broken oysters attracted fish at high tide. When the tide retreated the fish were stranded and easily collected.

The oldest archaeological remains found in north-eastern Queensland rainforests have been dated at about 5000 years old but the rainforests were probably inhabited much earlier.

Bookshelf

Aboriginal Life in the Rainforest
The Aboriginal people of Jumbun and Helen Pedley
Dept of Education, Queensland (1992)

This lovely book, illustrated with abundant photographs, looks at plant and animal use by the Jirrbal people of Jumbun at Murray Upper, north of Cardwell. An introduction is followed by chapters on the making of baskets, the processing of black bean and cycad food, the making of a traditional shelter and smoking an eel.

Cairns Botanical Gardens
There is plenty of reading matter on the subject of Aboriginal traditional plant use on the fifty-plus signs in the Aboriginal Garden section of the Gardens. There is also a good display in the Great Barrier Reef Aquarium in Townsville.

Aborigines and Toxic North-eastern Queensland Rainforest Plants
Nicky Horsfall
Chapter in: **Toxic Plants and Animals, A Guide for Australia**
Queensland Museum (1987)

A very interesting look at this subject.

Invasion and Resistance: Aboriginal-European Relations on the North Queensland Frontier 1861-1897
Noel Loos
Australian National University Press (c1982)

Understanding Country: the importance of land and sea in Aboriginal and Torres Strait Islander societies (Dermot Smyth) — Key Issue Paper No. 1
Valuing Cultures — Key Issue Paper No. 3
Council for Aboriginal Reconciliation
Commonwealth of Australia (1994)

These are two of a series of Key Issue Papers which are very well worth reading for a deeper understanding of these Aboriginal issues.

Information Kit on Native Title
Aboriginal and Torres Strait Islander Commission (1994)

This is one of many informative and useful sources of information available from ATSIC. There are regional offices in Brisbane, Rockhampton, Townsville and Cairns.

A Plain English Guide to the Wik Case
Aboriginal and Torres Strait Islander Commission (1997)

The Little Red, Yellow and Black (and Green and Blue and White) Book
A Short Guide to Indigenous Australia
Australian Institute for Aboriginal and Torres Strait Islander Studies (1994) on behalf of the Council for Aboriginal Reconciliation.

Film:
Mabo: Life of an Island Man

This moving film looks at the man behind the famous Mabo case and his fight to establish ownership to his traditional land in Murray (Mer) Island.

Tourist talk

ENGLISH	GERMAN	JAPANESE	
Aborigine	Ureinwohner	gen ju min	原住民
indigenous	einheimisch	dochaku no	土着の
traditional	traditionell	dentou teki na	伝統的な
culture	Kultur	bunka	文化
language	Sprache	gengo	言語
community	Gemeinschaft	shya kai	社会
toxic	giftig	doku no	毒の
cook	kochen	riyori suru	料理する
leach	auslaugen	kosu	漉す
medicine	Medizin	kusuri	薬