Tropical Topics

An interpretive newsletter for the tourism industry

Light in the rainforest

Vol 1 No. 5 September 1992

Notes from the Editor

Sunlight is food. Without it no plant 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 - openings in the forest canopy - producing different amounts of light (see page 2) is 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.) and the ability of the forest to regrow (by crushing saplings and compacting soil). Not least, these 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.

The solar panel canopy

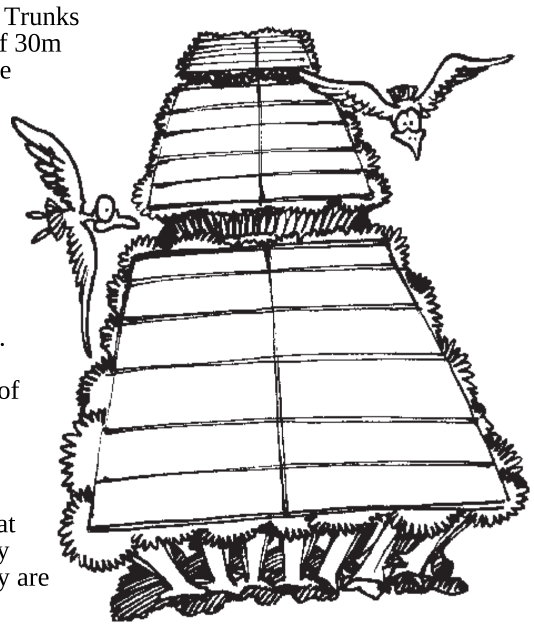
When we look down from an aeroplane on to the rainforest canopy we see a green roof – an almost solid mass of vegetation obscuring the ground below. What we are seeing are billions of leaves feeding. They are guzzling sunlight.

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 to receive the full force of the sun were recorded to be 10°C 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.



WET TROPICS

WORLD HERITAGE AREA

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.

Menu

at the

Photosynthesis Cafe

Chlorophyll
Essential for digestion of your meal, this tadpole-shaped molecule is tastefully arranged around a single atom of magnesium.

Sunlight
Strong, hot and spicy. A real energy booster after a long dark night.

Hydrogen
Tastefully combined with oxygen and presented in a crystal clear beverage.

Carbon and oxygen
Irresistibly combined in a heady concoction of carbon dioxide and wrapped in an invisible (and disposable) mix of nitrogen, oxygen, argon and water vapour.

More light notes

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.*

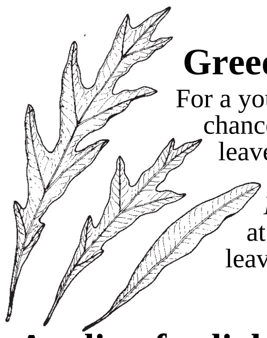
*Breathe in some air. Select the carbon dioxide and split it into **carbon** and **oxygen**. (Don't forget to breathe out excess oxygen. It keeps the animal kingdom alive.)*

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.



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.

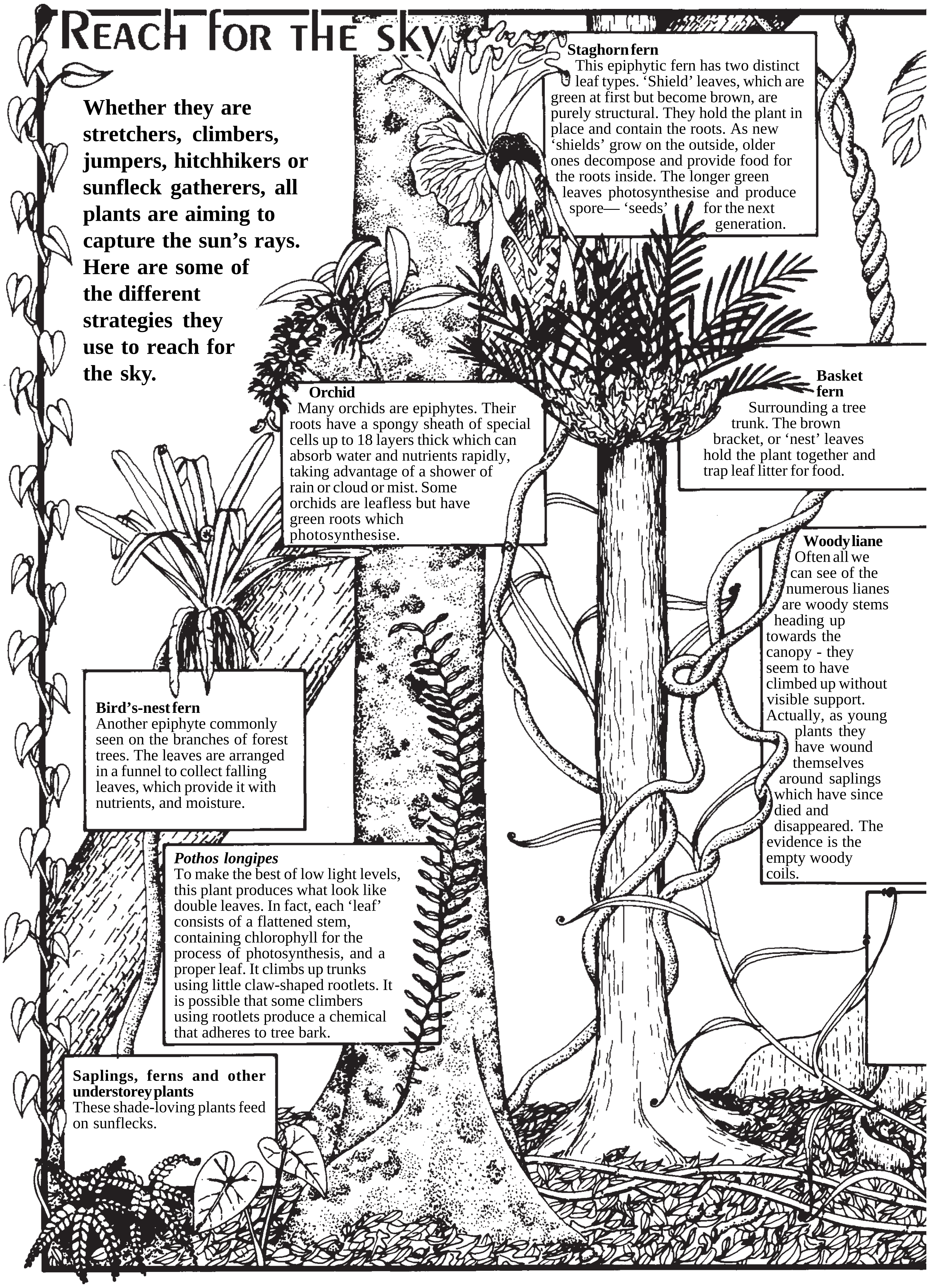
Gathering sunflecks

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.

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 spore— 'seeds' for the next generation.

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.

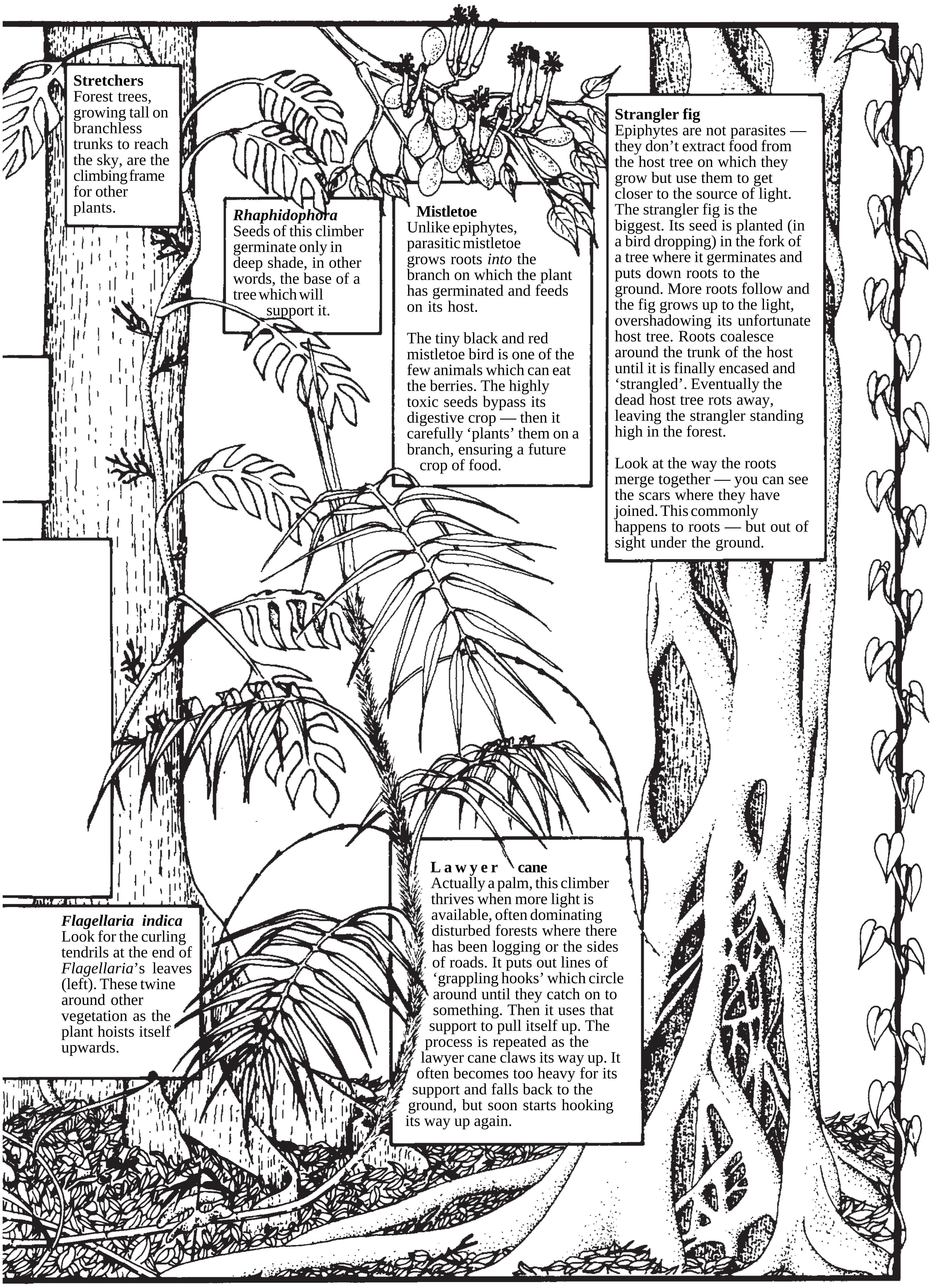
Basket fern
Surrounding a tree trunk. The brown bracket, or 'nest' leaves hold the plant together and trap leaf litter for food.

Woody liane
Often all we can see of the numerous lianes are woody stems heading up towards the canopy - they seem to have climbed 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.

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 highly toxic seeds bypass its digestive crop — then it carefully 'plants' them on a branch, ensuring a future crop of 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.

Questions & Answers

Q Why do marlin come in to the Lizard Island area at this time of year?

A From September to December, marlin from the north-west Coral Sea congregate just outside the reef, sometimes within a few hundred metres of the reef edge, to spawn. Main concentrations are in reefs off the Cairns - Lizard Island region.

From May to October, there are also concentrations of marlin around Cape Bowling Green, south of Townsville. In this case, they are juveniles in the 10-40kg, six months to two-and-a-half years old, bracket and are probably feeding on pilchards and herrings. Another billfish, the sailfish, also swims with the marlin.

More than 95 percent of the fish caught are tagged and released. However, after their long struggle, it is possible that many are exhausted and fall prey to sharks or simply drown.

Q The long-spined black sea urchin (*Diadema*) appears to have an eye on the top and four to five fluorescent blue spots. What are they?

A The 'eye' is, in fact, the anus. It is a flexible cone, or tube, which in one species, *Diadema setosum*, has an orange ring, like the iris of an eye. Watch the urchin and you will see it bend the tube over and distribute balls of faecal matter - the tube enables it to deposit it away from its body.

The fluoro spots have also been called eyes, but experiments showed them to be the least sensitive to light of all areas tested. The spots seem to be patches of tiny light-scattering structures known as iridophores. (Another type of iridophore produces the bright colours in the exposed fleshy mantle of the reef clam *Tridacna*.) The function is unknown. One suggestion is that the blue glow produced is diffused to light-sensitive areas of the body, increasing the sea urchin's ability to perceive differences in light and shadow. It certainly seems able to do this. Try putting your hand over the top of an urchin and watch it point its spines at the shadow, ready to defend itself against attack.

Q My bird book tells me that metallic starlings are migratory. This year, I have been aware of them all year. Just now I notice they are starting to nest again. Are they becoming sedentary?

A There are two possibilities. Metallic starlings which we are seeing around in the winter may have migrated from further south while those which nested in the Cairns area have migrated to the Cape York Peninsula or further north to New Guinea. It is also possible that juvenile starlings may hang around while adults do the migrating. An extensive banding programme would be necessary to determine exactly what happens.

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

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.

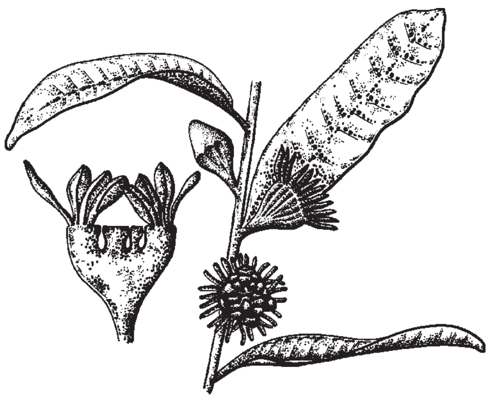
Almost all twiners twist themselves in an anti-clockwise direction — whether in the northern or southern hemispheres. Scientists are still trying to understand why.

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.

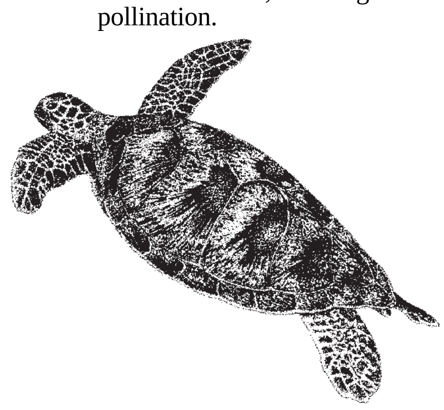
Nature notes

A diary of natural events creates a pleasing journal which grows richer with the passage of time. Watching for the recurrence of an event after noting it in a previous year, and trying to understand what could have caused changes in timing, is intriguing.

These notes are from the author's own notebook, or were offered by researchers and fellow naturalists. Readers will, inevitably, note variations between their observations and those appearing here. If you do not keep a nature diary perhaps this will inspire you to begin one.

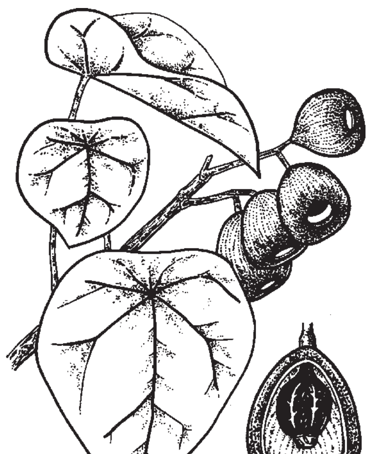


Spring in Wet Tropics rainforests will see the blossoming of a plant known as '**native guava**' (*Eupomatia laurina*). These flowers are thought to show some primitive characteristics. For example, what look like numerous white petals are, in fact, sterile stamens, revealed after the united petals are pushed off as a cap, similar to the process in eucalypt flowers. The sterile stamens are food for a small weevil which lives in close association with this flower, assisting in its pollination.

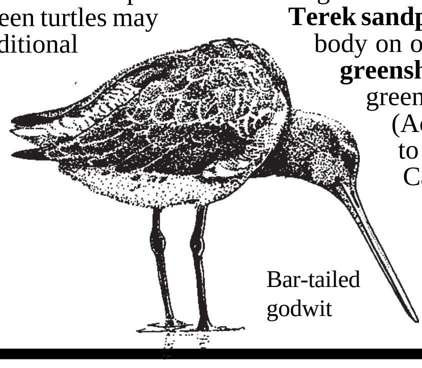


Female **green turtles** may begin mating during September, accepting and storing sperm from several males. During mating, which takes place at the surface, the shell of the male can be seen as an almost immobile lump on the water. Fertilised green turtles may begin egg laying at traditional beach sites about November, producing several clutches of up to 150 eggs at intervals until about March next year. (Acknowledgments to Mark Simmons of GBRMPA.)

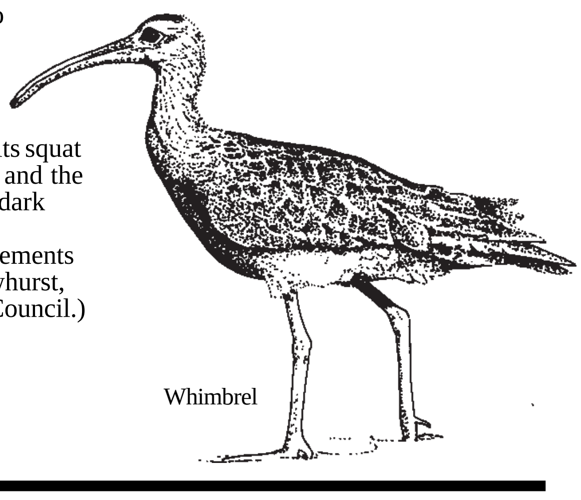
A small, glossy-leaved beach tree known as the **sea hearse** (*Hernandia nymphaeifolia*) should carry ripe fruit this month. The gloomy name is an allusion to its unusual fruit, a dark, ridged seed case, partially concealed within 'a loose smooth cream envelope with a circular opening at the top through which the black fruit can be seen ... the fruit's structure apparently suggesting a carved coffin surrounded by a pale shroud.' (Cribb, A.B. and J.W., 1985: *Plant Life of the Great Barrier Reef and Adjacent Shores*.)



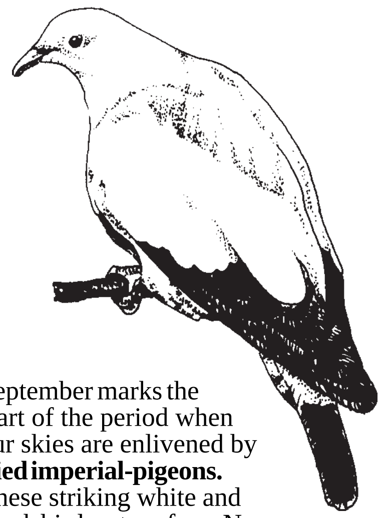
Numbers of **migratory waders** will also be reaching a peak during September, returning to our hemisphere after a busy breeding season in far-off nations to the north, during their summer. Most numerous of about 30 species of waders recorded on the Cairns mudflats are **sharp-tailed** and **curlew sandpipers** and **red-necked stint.** Relatively easy to identify are the large **eastern curlew**, its smaller relative, the **whimbrel**, and two species of **godwit** - the **black-tailed** and **bar-tailed**. Of the smaller species, two of the most recognisable may be the **Terek sandpiper** with its squat body on orange legs and the **greenshank,** with dark green legs. (Acknowledgements to John Crowhurst, Cairns City Council.)



Bar-tailed godwit



Whimbrel



September marks the start of the period when our skies are enlivened by **Pied imperial-pigeons.** These striking white and black birds return from New Guinea to nest offshore, on islands such as Hinchinbrook and Low Isles, as well as in trees on the mainland, including some lucky urban backyards. Rainforest fruits which feature prominently in their diet include many of the laurel family (*Cryptocarya* spp), lawyer palms (*Calamus* spp), figs and woodland trees of the Canarium family (*Canarium vitiense* and others).

Pied imperial-pigeons raise one young at a time, the parents taking turns to feed the nestling on 'pigeon milk' secreted from glands in the crop, a procedure common to all pigeons. Birds may raise a second offspring after the first fledges, but this has not been confirmed. (Acknowledgments to Francis Crome, CSIRO Wildlife, Atherton.)

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

This newsletter was produced by the Queensland Department of Environment and Heritage (now The Environmental Protection Agency) with funding from the Wet Tropics Management Authority.

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WET TROPICS MANAGEMENT AUTHORITY

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service