Tropical Topics

An interpretive newsletter for the tourism industry

Plants before flowers: focus on cycads

No. 59 December 1999

Notes from the Editor

As we get caught up in Millennium Fever it's interesting to look back at the past. However, 2000 years is just a blink of an eye compared with the 4600,000,000 years for which planet Earth has existed and the 3500,000,000 years life has been slowly evolving.

The recent TV series 'Walking with Dinosaurs' has also encouraged us to look back. Settings for the computer animations had to be chosen carefully. There were to be no grasses — they weren't around in those days. Instead tree ferns, cycads and conifers — the plants on which dinosaurs fed and which formed a backdrop to their dramas — were needed.

These plants have since been largely overwhelmed by the hugely successful flowering plants which evolved after them. Many have become extinct but, nonetheless, many have persisted as a fascinating link with the distant past. This *Tropical Topics* looks at those links and focuses on perhaps the most prominent 'dinosaur plants', the cycads. In future issues we will look at other primitive plants which still share our world today — the ferns, conifers, mosses, lichens and liverworts.

I would like to thank Gary Wilson of the Queensland Herbarium for his valuable assistance with this issue.

All thanks to the bacteria

When the Earth came into existence, about 4600 million years ago, there was little or no oxygen in the atmosphere of our planet. Indeed, life owes its origins to an apparently lethal combination — a thin atmosphere composed largely of hydrogen, ammonia, methane and carbon monoxide, hot oceans, ultraviolet rays which bombarded the earth's surface in the absence of an oxygen (ozone) shield and electricity in the form of abundant lightning. Laboratory experiments have shown that this combination eventually produces simple sugars, amino acids and nucleic acids — the basic requirements for protein synthesis.

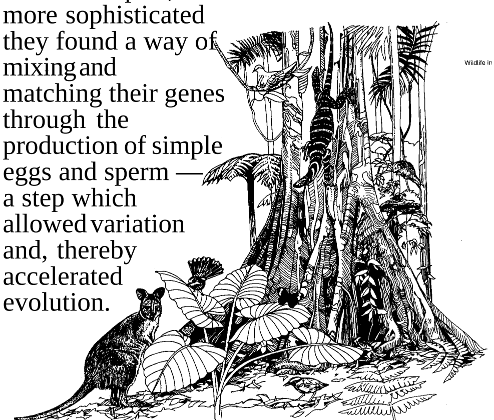
Eventually, after further interactions, DNA (deoxyribonucleic acid) appeared. Able to replicate itself and to cause formation of amino acids, this was the essence of life. Simple bacteria were the first proper life forms to emerge from this process, about 1000 million years after the formation of the planet. They started off feeding on simple carbon compounds but when these stores began to run low, a light-harvesting compound — chlorophyll — was developed which enabled some of these bacteria to create food from sunlight. This process required hydrogen, a gas available in abundant quantities from volcanic activity. However, this restricted the bacteria to volcanic zones, until one enterprising branch of the family developed a method for extracting hydrogen from an even more abundantly available source — water.

Waste products from this process were to have far-reaching consequences for the further development of life on Earth. When H is removed from H_2O, oxygen — the O — remains. Casually discarded by the bacteria as a waste product, this essential element of our modern air began to build up in the atmosphere.

The fashion for photosynthesising caught on in a big way and, as millennia came and went, huge amounts of oxygen were produced by vast numbers of microscopic bacteria all busily splitting water molecules to feed themselves. We have a lot to thank them for. Not only did they produce oxygen, but this also led to the creation of an ozone (O_3) shield against lethal amounts of ultraviolet rays. However, by excluding the very rays which kick started the whole process, these bacteria also ruined the chances of life ever beginning again in the same way.

At some stage, many many millions of years later, these primitive life forms became more complex and more organised. It is likely that some simple organisms engulfed others and, instead of digesting them, formed a partnership with them — perhaps rather like corals and zooxanthellae. Eventually the partners merged, forming one corporate body.

They also discovered sex. Instead of reproducing simply by dividing into identical copies, as life forms became more sophisticated they found a way of mixing and matching their genes through the production of simple eggs and sperm — a step which allowed variation and, thereby accelerated evolution.



WET TROPICS MANAGEMENT AUTHORITY

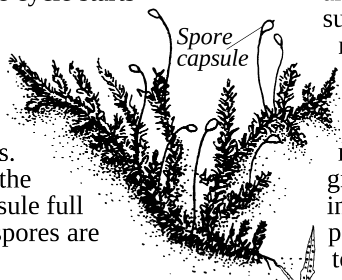
Queensland Government Environmental Protection Agency

Plants step on to land

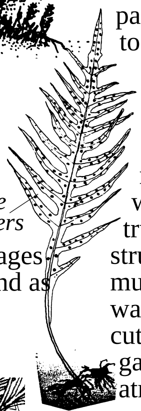
Algae were the first proper plants and it was from green algae that all the land plants eventually developed. However, leaving the water was no easy step. The body structures and the reproductive systems of early life forms, both plant and animal, depended on this watery environment.

Sexual changes

Algae have complicated sex lives involving **alternate generations**, one produced sexually and the other asexually. The mature plant divides asexually, by producing **spores**. These grow into different plants which, in turn, produce male and female cells. If, by swimming through water, these meet and fuse sexually they can then produce a mature plant and the cycle starts again.



This pattern of alternate generations was retained in early land plants such as **mosses**. Mosses produce female cells (eggs) attached to stems and sperm which are free to swim through the moisture in the plant towards the eggs. When fertilised, the egg germinates while still attached to the parent plant and produces the asexual generation — a capsule full of spores on a long thin stem. The capsule splits and the spores are distributed by the wind to grow into other moss plants.



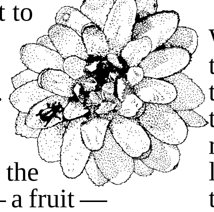
This pattern appears also in **ferns**. Spores are produced, often in clusters on the backs of the leaves, and are blown away to develop initially as tiny plants called thalluses. The underside of the thallus produces male and female cells, the sperm again swimming through ground moisture to fertilise the eggs, resulting in a mature fern plant.

All these methods of sexual reproduction required water, limiting the sexual stages to moist habitats, close to the ground. However, as plants moved on to land and as they grew taller, they needed to liberate themselves from this dependence. Thalluses were being shaded out and, on the ground, were being cropped by animals.

Cycads represent an important step in the sexual liberation of plants. By producing fertilised **seeds** on one of the parents they eliminated the necessity for alternating generations. They were among the first plants to reproduce above ground level. Male cells, in the form of pollen, were either blown or carried by insects from the cone on the male plant to the cone on the female plant. There sperm and egg united through a drop of water inside the ovary in the female cone — a last link to the watery ancestors — and a seed was formed.


Bunya cone

Conifers perfected **waterless fertilisation**, the male spore uniting directly with the egg at the end of its journey without first going for a swim. With both male and female cones produced on the same plant, chances of fertilisation were increased, wind blowing pollen from the male cone to the female one.



The first **flowers** were produced in west Gondwana, now west Africa, a trend which was to catch on in a big way. Although cycads had put to good use the insects' appetite for their pollen, flowering plants specialised in using animals as couriers for their sexual needs by providing attractive flowers and excess pollen and nectar in payment.

Of even more significance was the development in these plants of 'double-fertilisation', a process by which not only the ovary but also the ovary wall was fertilised so the seed was encased in an **endosperm** — a fruit — which provided food and protection for the seed. Magnolias and waterlilies are among the earliest flowering plants.

Flowering plants competed very efficiently with their predecessors, not least because they were able to grow faster. Nonetheless, conifers remain the dominant species in many temperate areas and cycads hang on in sometimes substantial numbers.

*Different sexual strategies did not evolve directly from one plant type to another. Evolution took different paths, with changes taking place on different branches of the tree of life. For example cycads are not related to conifers — or to any other group of living plants. Some temporarily successful plants, such as seed ferns, became extinct while others, such as ginkgos, became very restricted.

Structural changes

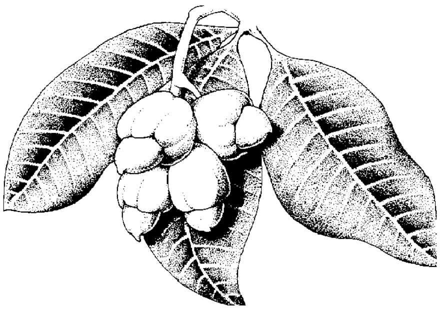
As plants left the water they had to adapt physically to their new surroundings. The first problem was finding enough water. Although they live on land, **mosses** are totally dependent on moist surroundings. They have no proper roots so the first adaptation to the environment came from those plants, club mosses, ferns and horsetails, which evolved true roots. These could probe the ground below the plants and tap into the water film surrounding soil particles, thus allowing the plants to move further from the coast.

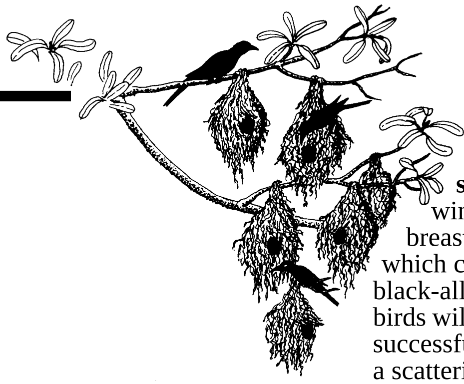
This water also had to be retained in the plant so those which ventured on to land needed a watertight skin. **Ferns** were the first plants to develop true leaves. Large spreading green structures, intended to gather as much light as possible, they had a waxy cuticle 'skin'. Pores in the cuticle allowed the exchange of gases with the surrounding atmosphere and stomata controlled the size of the pores, according to conditions.

Water, and nutrients, had to be circulated internally through the plant now that it was no longer possible to absorb them, as algae do, from their surroundings. Without the physical support of water, they also had to hold themselves up. Both problems were overcome by the development of the vascular system — a system of woody vessels which provided rigidity as well as a circulation system. Only mosses and liverworts, among today's land plants, are non-vascular.

With newfound structural strength, the plants started gaining height, those which grew tallest, like the tree ferns, being rewarded with the lion's share of the sunlight for photosynthesis. Ancient swamp forests were dominated by now extinct giant club mosses and giant horsetails growing on vast trunks to 45m in height. It is the remains of these giants which we now mine as coal.

Out and about



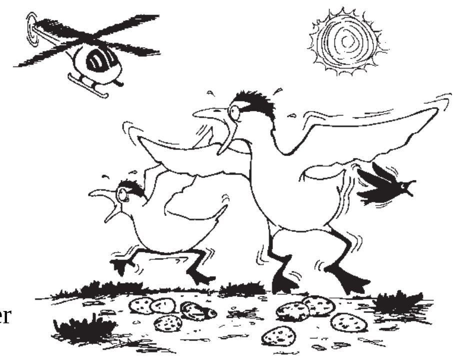


Newly-fledged **shining starlings** will now be on the wing, recognisable by their pale breast feathers, streaked with black, which contrasts with the iridescent black-all-over of the adults. Mature birds will tend another brood, successful hatchings being marked by a scattering of neatly halved blue eggshells under the nesting tree.

Beware the **tar tree**, *Semecarpus australiensis*, which produces its fruits between November and January. Reasonably common in coastal and lowland forests and beach suburbs, this tree is sometimes called the native cashew because the fruits look very similar. There is an orange fleshy section — which is actually a thickened stem — with a seed, like a cashew nut, attached to the end. In fact, the two trees are related.

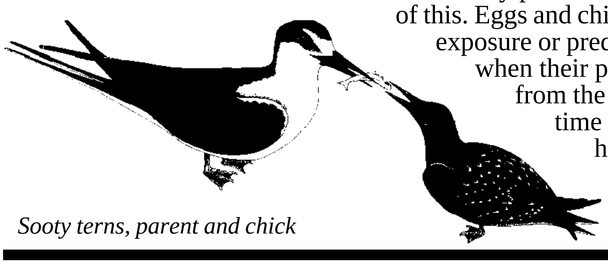
However, the tar tree contains potent chemicals. Although cassowaries eat it, the seed is toxic to humans and the tree and seed both contain a sticky sap which can cause painful blistering and severe skin irritation. The name tar tree describes the blackening of the patches of the trunk where the sap exudes due to wounding.

Some items, past their 'use-by date', have been removed from the web version of the newsletter.



Keep away from the Cay. At least if you are in a plane. Aircraft are banned from flying lower than 3000ft above **Michaelmas Cay** and within one nautical mile from its centre. Under an agreement between the Queensland Parks and Wildlife Service and Air Services Australia, the control tower at Cairns Airport has begun monitoring the Michaelmas Cay area with a new computer system which will provide early warning of possible incursions.

The reason for this is concern over the continuing decline in numbers of seabirds at this major nesting site. It is one of the most important sites in the northern GBR and the southern limit of sooty tern breeding on the Reef. Common noddies, crested and lesser crested terns also nest there in large numbers. However, numbers of some species have declined by up to 40 percent since 1984 and disturbance by planes has been blamed for some of this. Eggs and chicks can die quickly from exposure or predation by silver gulls when their parents are scared away from the nest. This is the first time airspace restrictions have been imposed on environmental grounds.

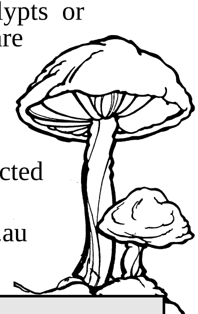


Sooty terns, parent and chick

The summer rains have produced an explosion of **fungi** fruiting bodies this year. If you are interested in these wonderful organisms you may like to have a look at the Fungimap website on www.rbg.vic.gov.au/fungimap

Fungimap is a collaborative project between professional and amateur mycologists and naturalists to gather information about the distribution of fungi throughout Australia.
The fungus flora of Australia is remarkably poorly known. While there are thousands of people who can identify orchids, eucalypts or wattles by sight, there are very few amateur or professional naturalists who can do the same for the fungi.
Fungimap can be contacted through:

fungimap@rbg.vic.gov.au



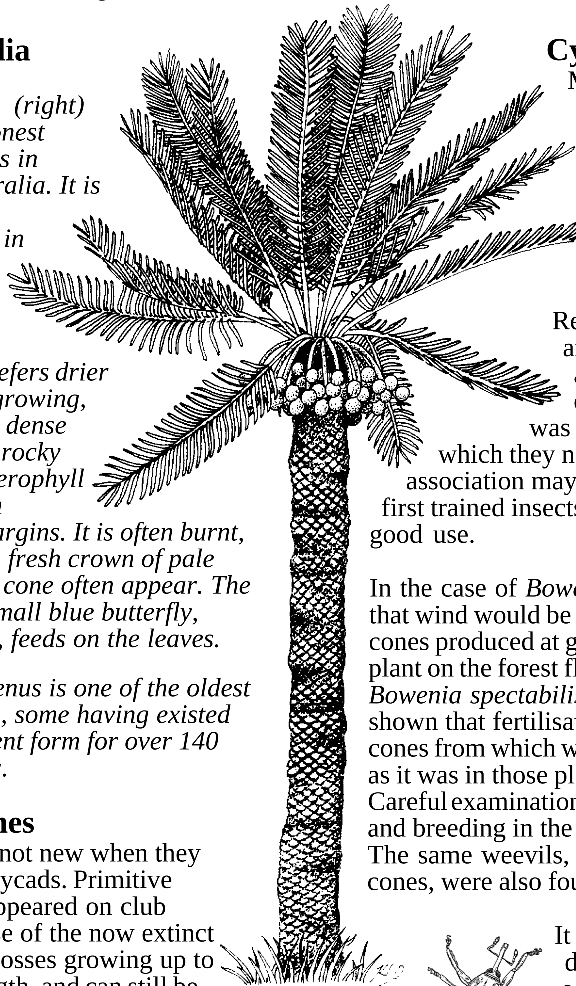
Concentrating on cycads

The Wet Tropics is the only place in the world where representatives of all three families of cycads, Cycadaceae, Stangeriaceae and Zamiaceae, can be found together.

Cycas media

(Family Cycadaceae) (right) is the commonest Cycas *species in eastern Australia. It is found in Queensland, in and outside the Wet Tropics, and in New Guinea. It prefers drier conditions, growing, sometimes in dense colonies, on rocky slopes in sclerophyll forest and on rainforest margins. It is often burnt, after which a fresh crown of pale fronds and a cone often appear. The larvae of a small blue butterfly, Miskins blue, feeds on the leaves.*

The Cycas *genus is one of the oldest of the cycads, some having existed in their present form for over 140 million years.*



Cycad cones

Cones were not new when they evolved on cycads. Primitive cones had appeared on club mosses, those of the now extinct giant club mosses growing up to 50 cm in length, and can still be seen on other fern allies such as *Selaginella* species. Pine cones are quite different to and more complex than cycad cones.

Male cycad cones are usually smaller than the female ones but may be produced in more abundance and more often. The scales of the cones are modified leaves which, in females, have ovules near to the base. As they mature, male cones become elongated and shed pollen, after which they quickly decay and die. When pollinated, most female cones increase in size and weight, those of *Lepidozamia peroffskyana* (a close relative of *L. hopei*) reaching 40kg or more.

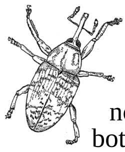
Cycads, wind and weevils

Many text books state that cycads are wind pollinated, like conifers. However, while the receptive female cones of conifers are open to air currents, those of most cycads are not. Wind tunnel tests of three species have shown that even when airborne pollen does settle on the female cones it usually does not land in a site suitable for fertilisation. In addition, many cycad species grow in isolation from each other — and it has been shown that certain cones can still produce seeds even when covered with forest debris.

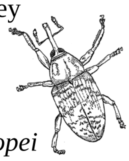
Research has now shown that at least some, perhaps even all, cycads are pollinated by insects. Indeed, five members of the Zamiaceae family and the two *Bowenias* in the Stangeriaceae family are now known to depend entirely on insects for pollination. While it is likely that wind was the pollination agent for cycads when they first evolved, the insects which they now use — mainly weevils — have very ancient origins so the association may have a very long history. Indeed, it may have been the cycads which first trained insects in the tricks which the flowering plants were later to put to such good use.

In the case of *Bowenias*, commonsense suggests that wind would be an unlikely pollination agent for cones produced at ground level from a low-growing plant on the forest floor. Recent experiments with *Bowenia spectabilis* and *B. serrulata* have shown that fertilisation was just as successful in cones from which wind and water were excluded as it was in those plants which were left alone. Careful examination revealed little weevils feeding and breeding in the tissues of the mature male cones. The same weevils, covered in pollen from the male cones, were also found in receptive female cones.

Bowenia spectabilis



It would seem that the *Bowenias* and the weevils are completely dependent on each other. The *Bowenias* cannot reproduce without the weevils (*Bowenias* cultivated from seed have very low fertilisation rates even when growing closely together) while the weevils are found nowhere else. They lay their eggs on the male cones, feed on the plant in both adult and larval forms and when the cones disintegrate they pupate in the soil below until the next season. Possibly the plant and weevil, having evolved together, are now unable (like the figs and their wasp pollinators) to survive without one another.



Similar weevils have also been found feeding and breeding on *Lepidozamia hopei* and, since they also carry pollen, are suspected of acting as pollinators for this species.

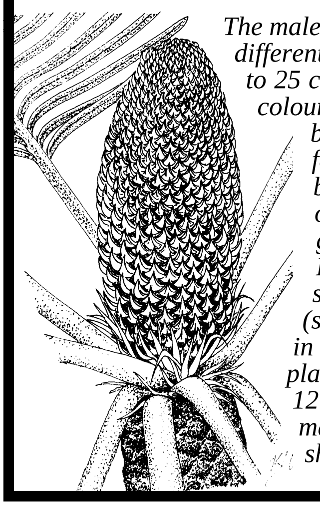
Native bees, belonging to an ancient family, have also been found collecting pollen from cycads, including *Cycas media* and *Lepidozamia hopei*. Perhaps they too will be found to act as pollinators.

Supersperms

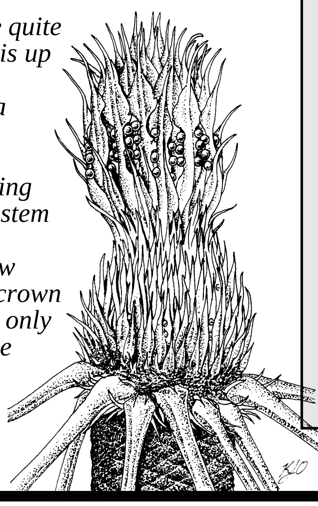
When the pollen grain arrives on the female cone it produces a long tube which burrows into the female cone (ovary) to reach the egg. When the tube is complete (which may take months) the pollen grain then produces the largest known sperm of any organism, plant or animal. This then swims its way down the tube to unite with the egg.

Cycads and ginkgos are the only seed-producing plants with motile sperm* — sperm with numerous hair-like cilia which move it along. This type of sperm demonstrates links with the more primitive ferns and mosses as well as the algal ancestors. It is an attribute which flowering plants were able to discard when animals became their sperm-couriers.

*Animals also have motile sperm.



The male and female cones of Cycas media *are quite different in appearance. The male cone (left) is up to 25 cm in length and an orange brown colour. The female cone (right) looks like a bunch of spiky leaves on which the fertilised seeds start to grow as green balls. These structures then relax, falling out from the crown of the plant as the stem grows through the centre of the cone. Eventually the ripening orange-yellow seeds hang down in a ring below the crown (see above). This habit, which is found only in females in the* Cycas *genus, allows the plant to grow more leaves during the 9-12 months the seeds take to ripen. The male cone, its usefulness relatively short-lived, simply falls off.*

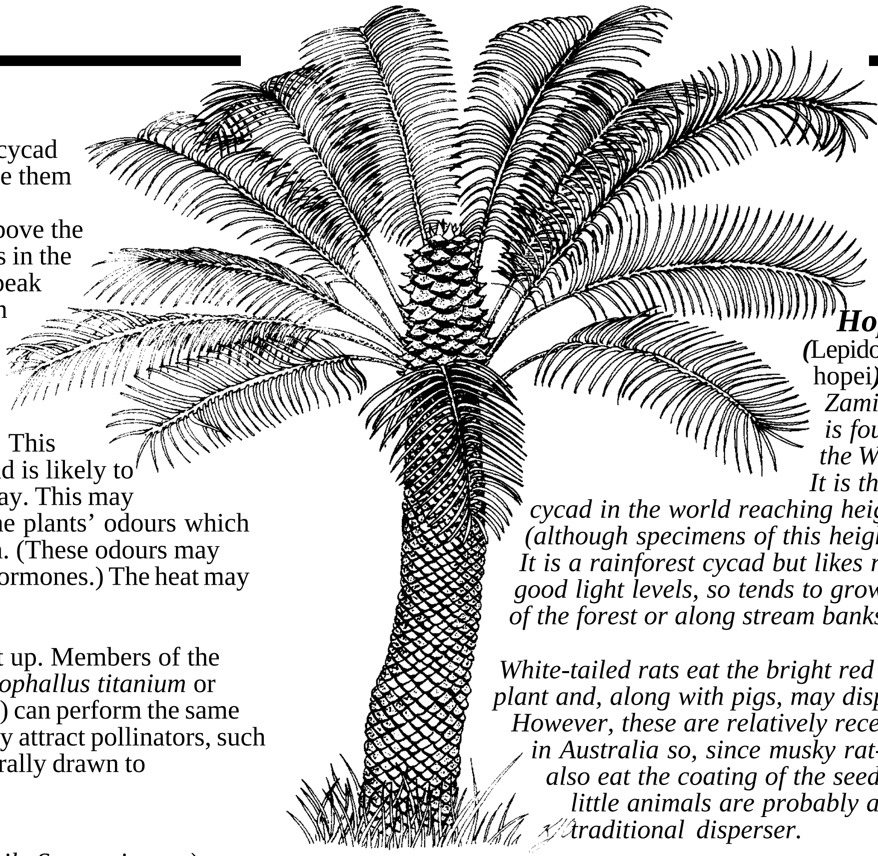


Hot sex among the cycads

If you use an infrared camera to view ripe cycad cones in the afternoon, you are likely to see them glow! The plants are able to increase the temperature of their cones up to 17 deg. above the local air temperature. This usually happens in the afternoon — between midday and 2pm is peak glowing time for *Bowenia* cones which can reach 6 deg. above the surrounding air temperature.

The heat is created by the breakdown of starch and lipids stored in the cone scales. This happens when the cones reach maturity and is likely to increase chances of fertilisation in some way. This may happen because insects are attracted by the plants' odours which become stronger when the cones are warm. (These odours may attract male insects by mimicking female hormones.) The heat may also help the male cones to shed pollen.

Cycads are not the only plants able to heat up. Members of the Araceae family, such as the giant *Amorphophallus titanium* or Devil's tongue of Sumatra (to 2m in height) can perform the same trick by warming up their flowers. This may attract pollinators, such as flies and carrion beetles, which are naturally drawn to decomposing bodies and animal wastes.



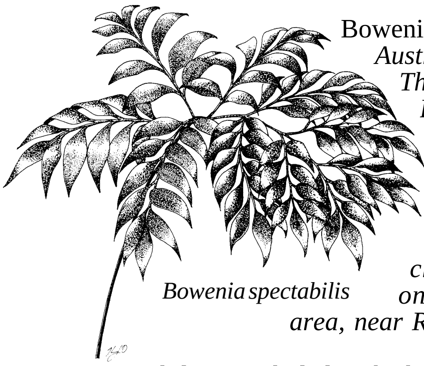
Hope's cycad

*(*Lepidozamia hopei*) (Family Zamiaceae) (left) is found only in the Wet Tropics. It is the tallest cycad in the world reaching heights of 20m (although specimens of this height are rare). It is a rainforest cycad but likes reasonably good light levels, so tends to grow at the edge of the forest or along stream banks.*

White-tailed rats eat the bright red seeds of this plant and, along with pigs, may disperse them. However, these are relatively recent arrivals in Australia so, since musky rat-kangaroos also eat the coating of the seeds, these little animals are probably a more traditional disperser.

Zamia fern (Bowenia spectabilis) *(Family Stangeriaceae)* *Despite its common name,* Bowenia *is not a fern — or even a* Zamia *(which are American cycads). The confusion with ferns is understandable, however, because it is quite different in appearance to the other cycads. Its slender branched leaves, grow just a metre or so in height, from an underground stem. It can be quite common in reasonably wet areas and is associated with rainforest or wet sclerophyll.*

Bowenias *are, by far, the most toxic cycads in the world, with the highest level of mercury. (See page 7 for more on toxins.)*

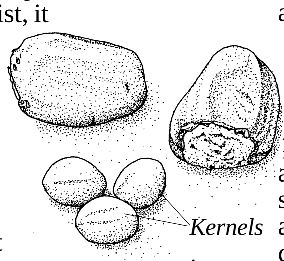


Bowenia spectabilis

Bowenias are *found only in Australia, in Queensland. There are two species. The Byfield fern,* Bowenia serrulata, *is very similar to* Bowenia spectabilis *but its leaves are serrated and the plants form multi-stemmed clumps. This cycad is found only in the Byfield area, near Rockhampton.*

Bowenia spectabilis *is included in the logo of the Wet Tropics Management Authority.*

Cycad seeds resemble fruits because they have a fleshy outer layer which is often brightly coloured. However, only flowering plants with double-fertilisation (see page 2) can produce true fruits. Although the fleshy layer keeps the kernel moist, it also contains chemicals which delay seed germination. When this is eaten by animals, as often happens, the seeds may germinate more quickly; experiments have shown this to be the case.



Slow cycads

Cycads are amongst the sloths of the plant world. Not only do the plants grow slowly but when fertilised, the seeds can take 12 months or more to mature in the cone. Even then, the embryos of most seeds are still immature and require an 'after-ripening' period of generally 6-12 months (in local species) before the seed can germinate.

Cycad roots

All species of cycads have special densely-branching roots which resemble corals in appearance and are found in no other plants. They grow on or at the surface and contain symbiotic blue-green algae/bacteria (similar to those which first brought us oxygen). Fixing nitrogen from the atmosphere, they allow the plants to live in poor soils. Studies of a West Australian cycad showed that the symbiotic blue-green algae in its roots can fix up to 35kg of nitrogen from the atmosphere per hectare per year.

This is possibly a very ancient arrangement dating back to the time when plants were taking their first steps on to land and may have been able to do so only by making symbiotic deals with fungi and bacteria.

Fires and cycads

Burning seems to encourage the production of cones in at least some cycad species. A comparison between a burnt patch of cycads (*Cycas* sp) and an unburnt patch showed that the burnt plants produced more than seven times the numbers of seeds.

Cycad history

Cycads first appeared about 230 million years ago. At that time there was only one land mass, now known as Pangea. The cycads therefore had about 50 million years in which to spread before this land mass made even the first split, into Laurasia and Gondwana. Their descendants are today found in tropical areas around the world.

Cycads had their heyday in the Jurassic Period, about 193-136 million years ago, along with the dinosaurs. The dominant vegetation type of the time, there were many more species than now remain. The ones which have survived to the present day are very little changed — but that does not mean that they have stopped evolving. *Bowenia serrulata,* isolated in the Byfield area, has become a separate species and genetic studies of different populations of cycads in the Wet Tropics, on either side of the Black Mountain Corridor (a dry zone which has caused long-term separation of many plants and animals) are showing slight changes as they gradually evolve in isolation from each other.

Questions & Answers

Q How long is the Daintree River?

A It's 120km long. The distance from the ferry crossing to the river mouth is 9.5km by river, or 7km as the crow flies. Estuarine crocodiles have been found as far as 68km upstream.

Q Please give me some information about Boyd's forest dragon — its life span, territory, breeding, etc.

A Boyd's forest dragon is only found in the rainforests of north-eastern Queensland. The male has a home range of about 1000 square metres. Female ranges are slightly smaller. Home ranges of the same sexes do not overlap but larger male territories often contain one or more female territories. Movements within the territories vary with season with dragons travelling 100m or more during summer days but relatively little in winter.

These lizards spend much of their time perching on the side of tree trunks just one or two metres from the ground waiting to ambush prey. They sometimes have favourite trees to which they will regularly return. They eat beetles, spiders, crickets and lots of ants. They also love earthworms. Although they may occasionally eat rainforest fruits, this seems to be rare.

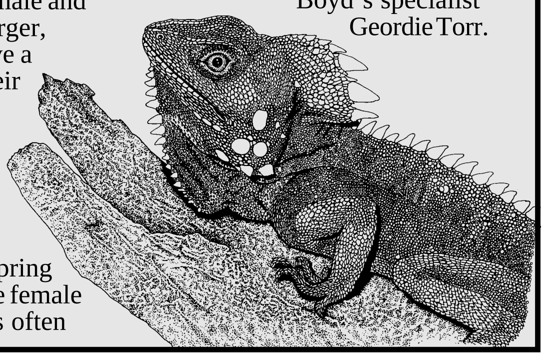
The male is larger than the female and can be distinguished by its larger, blockier head. Both sexes have a large yellow dewlap below their chins which they can erect using a bone called the hyoid. The dewlap is used for displaying to each other and to scare off predators.

The breeding season is late spring and early summer. At this time female dragons in the cooler uplands often move in search of open sunny spots, such as roads. They tend to sit on the roads, presumably using the warmth to help speed development of the eggs (a risky habit). Despite their fairly large size, forest dragons produce relatively small clutches, laying only one to six eggs at a time in a shallow hole. Unfortunately upland dragons often lay them in the warmer areas at the sides of roads where they are vulnerable to vehicles. Lowland dragons lay on the forest floor.

The lizards mature at about 1-3 years of age. They may live for about five or ten years but this is uncertain.

In general the forest dragon relies on its superb camouflage to escape predators. It will usually stay very still, only moving when it is sure it has been spotted. Then it slowly folds in its arms and legs and slides around the back of the tree, keeping the trunk between itself and its observer. The best way to spot a forest dragon is to carefully scan the sides of trees at about head height, while slowly walking through the rainforest. Examine any large bump — it may well turn out to be a lizard.

For more information on these lovely animals look at *Nature Australia* Vol 25 No 8 Autumn 1997 for an excellent article entitled **Forest Dragons** by Boyd's specialist Geordie Torr.



Tourist talk

ENGLISH	GERMAN	JAPANESE	
cycad	Cycaden	sotetsu	蘇鉄
moss	Moos	koke	苔
fern	Farn	shida	羊歯
conifer	Nadelbaum	shinyoju	針葉樹
cone	(Tannen-) Zapfen	kyuka	毬果
oxygen	Sauerstoff	sanso	酸素
bacteria	Bakterien	saikin	細菌
to pollinate	bestäuben	jufun suru	授粉する
primitive	urzeitlich	genshi tekina	原始的な
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Facts and stats

There are 250 species (11 genera) of cycads in the world. In Australia there are about 69 species (4 genera).

Growth rates for cycads probably vary according to nutrient levels and some large specimens are certainly hundreds of years old. Two *Lepidozamia hopei* plants were estimated to have grown at the rate of 8.5cm and 6cm per year, respectively. Cycads do not produce tree rings. Radio nucleotide decay rates (resulting from A bomb tests) have been used to indicate recent growth rates of some.

Cycads have roots and stems which can contract, pulling the plants stems underground! In some species the stem length may decrease as much as 30 percent.

Timelines

In order to gain a perspective on the unimaginable numbers of years involved in the history of life on Earth it is sometimes helpfully compared with a single year, one day representing ten million years. (This timeline focuses on plant evolution.)

- The year starts in January with the beginning of life, the ancestral bacteria, about 3500 million years ago.
- The first algae may have appeared sometime in August.
- Plants first began to colonise the land in the 3rd week of November.
- Treeferns and clubmoss forests developed about the beginning of December.
- Cycads appeared a week or so later.
- Flowering plants appeared about mid-December.
- (In the evening of the 31st December hominids appear, modern man arriving at the party just a few minutes before midnight.)

Animal parallels

Interesting parallels have been drawn between the development of land-based plants and animals.

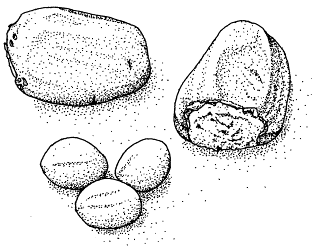
- Algae, with their free-swimming sex cells, are like the fish which shed their eggs and sperm into the water, allowing them to swim together.
- Spore-producing vascular plants such as ferns, horsetails and clubmosses are like amphibians which, although they lived on land, had to return to the water to breed.
- Seed-producing cycads and conifers are like reptiles which developed watertight eggs, allowing them to reproduce on land.
- Flowering plants, with their enclosed seeds, are like mammals which retain and protect the fertilised egg inside the mother's body until it is relatively mature.

Toxins in cycads

All cycads are poisonous. They have created their own unique toxins — cycasin and macrozamin (methoxyazomethanol glycosides). These include mercury which is probably accumulated from small quantities present in the soil. They attack the liver in humans and can cause cancer. Cycads have a long history of evolving alongside insects and other animals which saw them as likely tucker — and they have had all that time to prepare their defences.

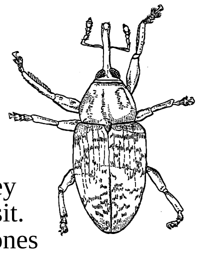
A number of early European explorers in Australia found this out the hard way. The earliest report of poisoning goes back to a Dutch expedition to Western Australia in 1696 and members of Cook's expedition made the same mistake after assuming that the seeds were safe to eat when they found cycad 'hulls' near Aboriginal fires at present-day Cooktown. They are apparently tasty with a starchy flavour similar to beans, chestnuts or hazelnuts. Although these experimenters lived to tell the tale, Cook's 'hogs' apparently died as a result of eating the seeds. Indeed, cycad seeds as well as leaves are known to be toxic to cattle, sheep and other livestock. These animals are particularly tempted to feed on young leaves which are often the first greenery to appear after a fire — but that is when the leaves are at their most toxic. Given the effects on humans and livestock, it is certainly curious that a number of native animals — and feral pigs — are able to eat the seeds without apparent ill-effect.

Despite their toxicity, cycads are widely eaten by humans. The seeds were such an important staple for Aboriginal people that cycad groves were 'farmed' to a certain extent by being burned regularly — this method also serving to keep the area clear of rainforest which would shade out *Cycas media*, the main staple. Since a mature female tree can produce a crop of 500 seeds, this was a reliable food source and many of the taller trees have steps cut into the trunks for ease of access. However, safe consumption depends on careful preparation which entails pounding the kernels, drying them and leaving them to leach in a dilly bag in first running and then still water for a week or more. The contents are then ground into a paste and baked. *Bowenia* roots were also eaten, following extensive and careful preparation.



Ill-effects from eating too many cycad seeds became apparent in Guam following World War II. Deprived of supplies, the locals had to rely almost entirely on cycads which were otherwise just an occasional part of their diet. Unfortunately the cycad toxins strip away the 'insulating' layer of myelin around the nerves allowing nerve impulses to 'leak' causing unpredictable movements as the nervous system gets out of control. An entire generation in Guam suffers from this syndrome, which is absent from younger generations who did not have to eat the cycads.

Weevils find a way



Although cycad toxins protect them from many herbivores, there are exceptions. Studies of the weevils which pollinate *Bowenia* have shown that they are able to feed on the starchy tissues of the male cones — but that they do not feed on the female cones they visit. A few bite marks found on the female cones indicate that they stop after a brief experiment. The reason is that while the toxins flood the tissues of the female cone, on the male cone they are enclosed in cells within the tissues. These toxin cells pass right through the digestive tracts of the weevils (they have been found, intact, in the poo). This enables a very small animal like a weevil to cope with toxins in the male, but not in the female. A larger animal, however, would get a mouthful of toxins from either cone.

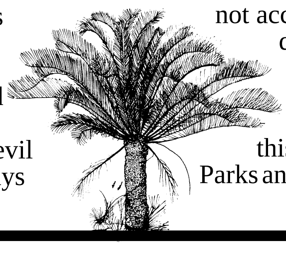
This method ensures that the weevils, which are so important to the pollination of *Bowenia*, are rewarded with food (and brood sites) only in the male cone. This makes sense because the male cone is dispensable once the pollen has been shed but it is important that the female cone is untouched since it needs to persist for much longer while the seeds develop. Why then do the weevils visit the female cones? They may be tricked into visiting by smell but they may also visit to receive rewards — a type of nectar produced at the entrance of each ovule.

People and cycads

Despite their toxins, cycads have been an important source of food wherever they grow. In many parts of the world the starchy centre of the trunks is dried, leached with water before being prepared as pellets known as sago. (Commercial sago is derived from certain palm species which are not even remotely related to cycads .)

Nowadays, cycads are valued more for their visual appeal, in gardens, parks and flower arrangements, than as food. Leaves are very long lasting and can be dried for wreaths and flower arrangements. However, this popularity has led to over-exploitation of wild stocks and the extinction in the wild of some species. As the plants become rarer, their value increases as does the temptation to illegally collect and trade in them.

A further problem of collecting is that it has the potential to affect the insect pollinators on which the future of the plants depend. If the association between the cycads and their specific insect pollinators is broken and both lose the ability to reproduce, they may both face extinction. This will happen if seeds are removed from the wild to be raised in isolation and also if the insects are affected by pesticides; the pollinating weevil of one South American cycad was wiped out by sprays directed against pests in nearby banana plantations.



Managing people

The Australian cycads are all listed under CITES (the Convention on International Trade in Endangered Species). Trade is allowed in these species only if the country of origin considers that the quantities traded do not represent a threat to the natural populations.

In Queensland all cycads are protected under the Nature Conservation Act 1992. They are all listed under Schedule 12 which means that no one can take or deal with the plants without a licence. This restriction refers to all parts of the plants, including seeds and leaves, and restrictions apply to all land tenures, including private land. Any plants (or plant parts) which are sold (or given) must be tagged with the appropriate permit. The popularity of cycads, and the restrictions placed upon them, has encouraged a black market. Please help to protect these marvellous plants by not accepting or selling any cycads which do not have the appropriate tag.

For further information on this, contact the Queensland Parks and Wildlife Service.

Bookshelf

Life on Earth
David Attenborough
Collins (1979)
Reader's Digest (1980)

In his inimitable way, David Attenborough relates the story of the evolution of life on earth in an accessible way.

The Nature of Hidden Worlds
Mary E. White
Reed Books (1993)

The Greening of Gondwana
Mary E. White
Reed Books (1993)

Both these books focus on the fossil history of Australia, the second focusing mainly on the plants of the prehistoric past.

Cycads of the World
David L. Jones
Reed books (1998)

This is a marvellous book on cycads. It covers all living cycads around the world and has a thorough introduction covering the history and prehistory of these plants, their structure and biology, their economic importance and cultivation.

Encephalartos No. 52 December 1997 Journal of the Cycad Society of South Africa

Notes on the Biology of *Lepidozamia hopei* Regal (Zamiaceae)
Gary W. Wilson and Peter C. Rowles

A study of our rainforest cycad.

Insect Pollination in the Cycad genus *Bowenia* Hook. ex Hook. f. (Stangeriaceae) Submitted
Gary W. Wilson

Australian Natural History (Nature Australia) Vol 24 No 11 Summer 1994-95
Cycad sex

A short article on hot cycad cones.

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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