THREE CONFERENCES

Encounters with whales
Conference for tour operators, resource managers, researchers, educators, conservationists and other interested parties
Lady Elliot Island
Sept. 6-10th
Five days of workshops, discussions and activities in a unique coral cay setting to explore future management of human/whale interactions.
For details contact:
Education and Information Section
GBRMPA Ph: (077) 81 8811

• • • • • • • • • • • • •

Caring For Our Coasts
MESA (Marine Education Society of Australia)
Gold Coast
Sept. 26th - Oct. 1st
Pre-conference Field Trip
Lady Elliot Island
Sept. 22-25th
For details contact:
Jan Thornton Ph: (075) 88 2222

• • • • • • • • • • • • •

Volunteers in step
A national conference for volunteers in the arts, tourism, environment and heritage.
Townsville
Sept. 8-10th
For details contact
Pat Kirkman Ph: (077) 21 2399

More CAFNEC walks and talks are planned. For details phone (070) 321746

Bookshelf

Reader's Digest Book of the Great Barrier Reef
Reader's Digest Services Pty Ltd., Sydney (1984)

Fourteen entries under the heading *symbiosis* in the index lead the reader to a variety of examples.

Australia's Great Barrier Reef
Robert Endean
University of Queensland Press (1982)

Good information with particularly interesting sections on The Reef Builders - Algae, How Living Space is Shared on Coral Reefs and How Nutrients are Shared on Coral Reefs.

The Marine Biology Coloring Book
Thomas M. Niesen
Barnes and Noble Books (Harper and Row Publishers) (1982)

'For students of marine biology and beachcombers.' Each section is composed of a page of text opposite a page of illustrations complete with colouring directions. Each deals with a different topic and although American in emphasis much is applicable to the Great Barrier Reef.

Australian Seashores
W.J. Dakin
Angus and Robertson (1980)

Field Guide to Anemonefishes and Their Host Sea Anemones
Daphne G. Fautin and Gerald R. Allen
Western Australian Museum (1992)

Corals of Australia and the Indo-Pacific
J.E.N. Veron
University of Hawaii (1992?)

A Coral Reef Handbook
Patricia Mather and Isobel Bennett (eds)
Surrey Beatty and Sons Pty Ltd (1993)

Sea Cucumbers of Northern Australia
L.R.G. Cannon and H. Silver
Queensland Museum (1986)

Particularly stunning photo books

Coral Reefs: Nature's Richest Realm
Roger Steene
Crawford House Press (1990)

Within a Rainbowed Sea
Christopher Newbert
Beyond Words Publishing Company (1987)

This newsletter was produced by the Queensland Department of Environment and Heritage with joint funding from the Wet Tropics Management Authority and the Great Barrier Reef Marine Park Authority.

For further information contact...

Stella Martin
The Editor
'Tropical Topics'
Department of Environment and Heritage
PO Box 2066
(10 - 12 McLeod St)
CAIRNS QLD 4870
Ph: (070) 52 3055
Fax: (070) 52 3080

Wet Tropics Management Agency
PO Box 2050
CAIRNS QLD 4870
Ph: (070) 316 555

Great Barrier Reef Marine Park Authority
PO Box 1379
TOWNSVILLE QLD 4810
Ph: (077) 81 8811

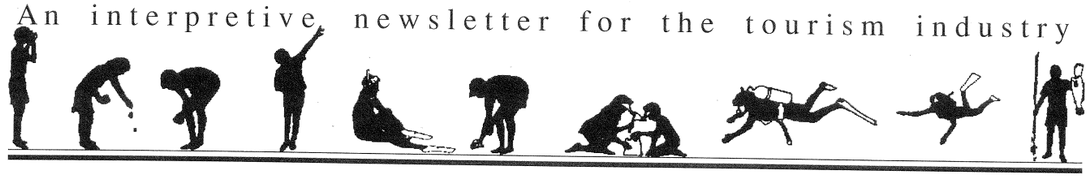
Wet Tropics theme next issue

Queensland Department of Environment and Heritage

Printed on 100% recycled paper.

Tropical Topics

An interpretive newsletter for the tourism industry



Reef relationships Vol 1 No. 14 August 1993

Notes from the Editor

Following last month's theme of relationships between forest plants and animals, in this issue we look at the same subject in the reef environment.

The waters of the Great Barrier Reef are so poor in nutrients that they have been compared with a desert, yet in that desert thrives an oasis as productive as any rainforest. Like a rainforest almost all the nutrients are contained within the living system - not in the surrounding sea (or soil) - and are constantly recycled through a variety of interactions between its inhabitants.

Like any finely-tuned system, however, the reef is vulnerable. The removal of too many nutrients by overfishing or the introduction of too many from pollution (including sewage and food scraps from boats) or fertilisers can easily tip the balance and damage the system. We need to be careful of the treasure on our doorstep.

Good news

New courses for tour operators will be starting up at the Cairns campus of TAFE in the new year. Called Heritage and Interpretive Tourism, a full-time course will lead to a certificate and, eventually, an associate diploma. Any modules can also be undertaken on a part-time or one-off basis. We will bring you more news of the course in future issues of *Tropical Topics*.

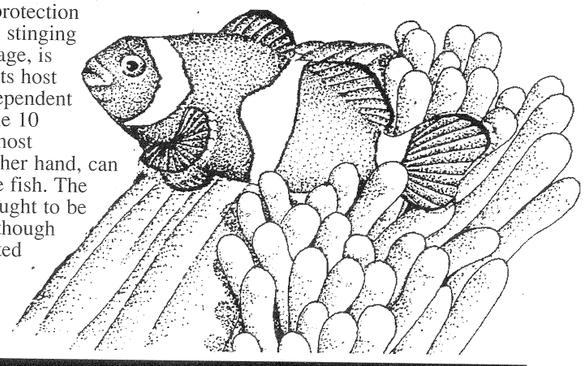
Reef relations

Eat and be eaten is the basic interaction in nature but it is by no means the only type of relationship existing between the numerous organisms of the reef. Associations range from those where two creatures happen to share the same living space to those where each is entirely dependent on the other and neither could live alone.

Where living space is at a premium every possibility has been exploited. For example, over 40 species of shrimps have been recorded which live on corals and nowhere else. (They are termed 'obligate commensals'.) Huge numbers of other creatures live on corals, anemones, urchins, sponges, feather stars ... the combinations and adaptations are endless. Some do no harm to their hosts while some, like the numerous boring organisms in coral, can be destructive. Some have found ways to avoid the defensive stings and poisons of their hosts while others have found ways to use them to their own advantage. A relationship may benefit both parties while another may be a case of parasitism - but often the nature of the association is unclear. The dividing line between types of relationships can be blurred.

The association between the anemone fish and the anemone has been known to science since 1868. The fish, which gradually acquires protection from the anemone's stinging cells at the junior stage, is never seen without its host and is completely dependent on its protection. The 10 species of potential host anemones, on the other hand, can be found without the fish. The relationship was thought to be strictly one-sided although observations suggested that anemones did better with fish in place and it had been suggested that the fish may help to clean and fan water to their hosts. (In aquariums the fish have been observed feeding the anemones but it is thought unlikely that this would happen in the wild.)

Then scientists removed the fish from one species (*Entacmaea quadricolor*) to see how long it would take for them to be repopulated. Within 24 hours the anemones had been eaten by butterfly fish. A feeder of coral the butterfly fish would presumably be immune to the stings of the closely related anemone but until then it had not been appreciated that perhaps the anemone fish actually protected its protector. Obviously, as many anemones do thrive without the fish this is not always the case and may apply only to certain species of anemone. But it does demonstrate how tight, in the crowded conditions of the reef, so many of the interrelationships are.



Marine Parks

Great Barrier Reef Marine Park Authority

Queensland Department of Environment and Heritage

Plants on the reef

All life depends ultimately on plants and their ability to convert the sun's rays to food. This is the basis of every ecosystem - without it there would be no animals. The reef is no exception - but where are the plants? Apart from seagrass patches plant life is not obvious. Nonetheless the plants are there.

•There is **algal turf**, a fuzzy green carpet which covers dead coral, rubble, etc. (Living corals suffer if free-living algae grow over them and block out the light so defend their territory from potential settlers.) It is kept closely cropped by herbivorous (plant-eating) fish, crustaceans, etc., but a cage excluding these grazers is soon filled with lush growth.
•There are **coralline algae** which play a major role in the formation of the reef. Some, which produce calcium segments in their skeletons, are responsible for up to 80% of the sand which fills the spaces between the reefs. Others, the encrusting pink algae, consolidate this packing, fortifying the reefs against wave damage. They are the dominant organism on the most exposed parts of the reef.
•There is **phytoplankton**, microscopic plants which constitute, along with zooplankton (animal plankton) a vast drifting soup of nourishment for many animals.
•And there are **zooxanthellae**.

Zooxanthellae - the hidden producers

It has been observed that in the rainforest the animals hide in the plants while on the reef the plants hide in the animals. Though tiny and easy to overlook, these algal plants, known as zooxanthellae, are 'farmed' as the main source of food for most of the reef corals and a range of other animals.

Coral collaboration

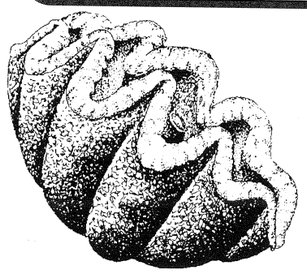
The association between certain coral species and their resident zooxanthellae is not only a wonderfully efficient example of mutual benefit and dependence but is also one of the most important symbiotic relationships on the reef.

Some of these hermatypic corals (those without zooxanthellae are called ahermatypic) start out in life with their algae on board, having been provided by the parent corals. Species without this 'packed lunch' generally obtain them at the free-swimming larval stage. The algae take up residence inside the coral polyp's tissue cells where they are responsible for the brown and yellow colours.

The zooxanthellae and the coral polyp effectively divide up the available resources, each utilising waste products from the other. The polyp 'breathes' water, using the oxygen and expelling carbon dioxide. The zooxanthellae use their green matter (chlorophyll) to produce energy from sunlight and combine this with carbon dioxide and water to produce food. Also necessary for this process are nitrogen and phosphate - produced as waste by the polyp and derived from the small zooplankton which make up 10% of its diet.

When it is exposed to the polyp's digestive juices the algal cell becomes 'leaky' and loses approximately 90% of its photosynthetic products to its host. This seems like daylight robbery but without the coral's input in the first place the algae would have difficulty producing *any* food in the nutrient-poor ocean. Similarly those corals without resident algae must work much harder, relying entirely on their ability to capture food with their tentacles.

The benefits don't end there. The algae are provided with a safe home and the coral with free building blocks; when obtaining carbon dioxide from water the algae dump the attached calcium carbonate - just what the coral requires to build its skeleton. In this way, tiny coral polyps build up massive coral reefs.



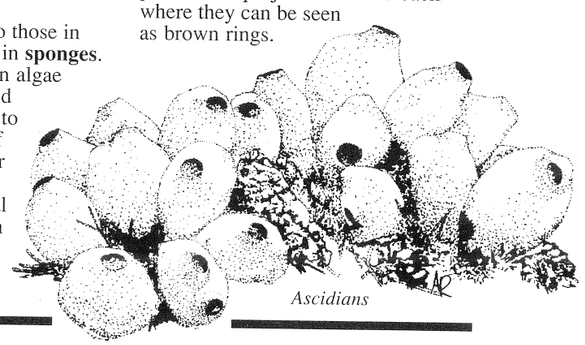
Giant **clams** (*Tridacna*) are also algal farmers. They pick up their zooxanthellae by eating it at day five of the larval stage. The plant cells then manage to pass unharmed from the gut wall to the mantle where they live in a 3-10mm thick layer producing up to 100% of their host's food. Clams are able to survive well in clean, nutrient-free water but for functions such as spawning may need to obtain some dissolved organic matter by filter-feeding. However, it is their relationship with zooxanthellae which enables them to achieve their massive sizes of over one metre.

A variety of other animals also farm algae. Certain **anemones**, which are close relatives of corals, are bright green in full light but become pale when their zooxanthellae are deprived of light. Another zooxanthellae-farming relative, the upside-down **jellyfish** (*Cassiopeia*) is commonly found sitting, anemone-fashion, on the sea bottom around mangroves. A few species of **flatworms** harbour algae and deliberately sun themselves each day so the plants can flourish.

A different sort of algae to those in corals and clams is found in **sponges**. These primitive blue-green algae have a special red-coloured protein which helps them to maximise the blue light of deep water and allow their sponge hosts grow most prolifically below the coral zones. Another blue-green alga lives in association with about 40 species of **ascidian**s, or sea squirts.

The relationship is so close in some species that neither can live without the other. The ascidian larvae even have special hairs and organs to collect algal cells from the parent colony before they depart to set up a new one.

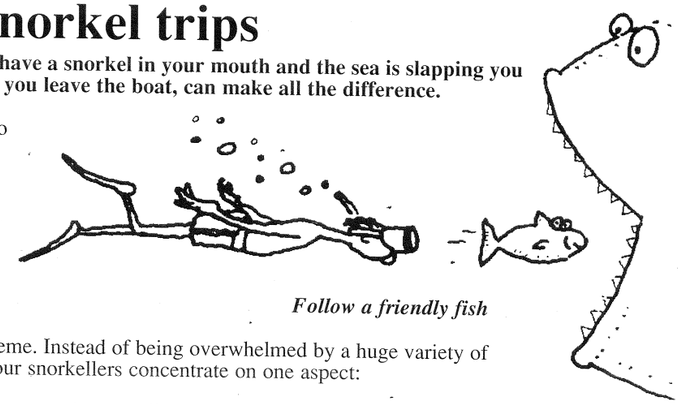
Then there are the thieves! A species of **nudibranch**, *Phyllodesmium longicirra*, feeds on soft coral removing its zooxanthellae and lodging them in the tissue of flat paddle-like projections on its back where they can be seen as brown rings.



Ascidians

Tips for guiding snorkel trips

Communication can be difficult when you have a snorkel in your mouth and the sea is slapping you in the face but a bit of preparation, before you leave the boat, can make all the difference.



Follow a friendly fish

You can give underwater slates and pencils to the snorkellers. They can then record or sketch fish, etc. they see and consult identification references on board. Or give identification charts to keen snorkellers. You could make your own, outlining a general form for each major fish family (wrasses, parrots, cods, damsels, etc.) and for other commonly seen creatures.

Try developing your snorkel tour around a theme. Instead of being overwhelmed by a huge variety of colour, pattern and movement suggest that your snorkellers concentrate on one aspect:

•Look for patterns, examples of camouflage, countershading, disruptive colouring, warning, etc. (See *Tropical Topics* 10 for fishy examples of these but other animals show these characteristics too.)

•Follow a friendly fish (parrot, butterfly or puffer) and observe colour and pattern, size and shape (fins and mouth location), how it moves, feeding habits, how it perceives and reacts to its environment and its responses to the snorkeller and to other fish. Does it have any special relationship with another organism or is it particularly territorial?

•Watch out for interactions between reef inhabitants. Find examples of aggression and territorial behaviour, such as damsel fish in clumps of coral or war zones between different coral or anemone species. Are creatures demonstrating defensive behaviour, for example, nudibranchs advertising their toxins, crabs with anemones or sponges, or Christmas tree worms retreating into their tubes? Look for holes in shallow sandy flats with a goby standing guard. Is there a shrimp 'cleaning house'? Run your hand through some bright green turtle weed and gently tease out the pale green crab. What is their relationship? Keep an eye out for the cleaning stations of cleaner fish and shrimps and watch them go to work.

Don't forget your torch - to light up deeper crevices and show colour absorbtion at depth. Wear red swimmers and 'duck dive' down to demonstrate.
Contributed by Julie Swartz, QDEH

Please remember that feeding of marine life on the reef is regulated. For guidelines see *Tropical Topics* 10 or contact GBRMPA. Dumping your scraps overboard could attract not only the fish but a fine as well!

News from the Innisfail Volunteers

A warm welcome to the Innisfail Volunteers who recently completed their training course. This covered issues ranging from the principles of park management to weed control and the care and maintenance of our local crocodile population. Volunteers visited Eubenangee Swamp with naturalist Peter Stanton and woke to a rather damp dawn chorus at Palmerston National Park on their camping weekend.

Once the course was over the volunteers' services were requested at the Cassowary Carnival at Mission Beach State School where a couple of the bravest tried their hands at puppeteering. Volunteers also researched a display about weed control which they presented at the Innisfail show. Track work, park cleanups and interpretive displays are on the agenda for the next few months.
Contributed by Deb Cavanagh, volunteer co-ordinator.

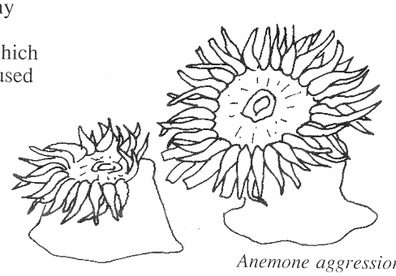
War on the reef

Crowded conditions, where living space is limited, are notorious for causing friction between neighbours and the reef is no exception.

Fish, crabs, etc. behave in a recognisably aggressive way to intruders. However it is thought that at least some creatures residing in a particular coral colony have methods for communicating with each other. Presumably this system ensures that inhabitants do not attack each other, because intruding outsiders, even of the same species, may be identified and chased.

Even creatures which are relatively immobile become very territorial. Many resort to chemical warfare, poisoning their neighbours with toxic secretions. Sponges, anemones, soft corals, ascidians and algae of many species protect their living spaces with strong antibiotics, some of which have been isolated and are being used for medicinal purposes.

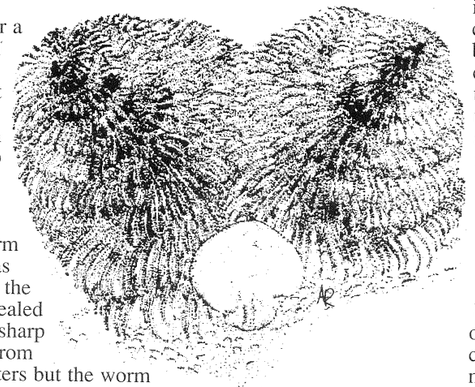
Corals are particularly territorial. Fast-growing species may simply overgrow slower ones, cutting off the light to the zooxanthellae. More actively aggressive species extend their stomachs and digest the tissues of their neighbours! Other species produce a number of very long 'sweeper tentacles' which sting the neighbouring colony, sometimes to a distance of several centimetres. The result is a sort of no-man's land between the colonies composed of the dead coral of the loser. Generally the more aggressive corals are the slower-growing ones so a balance is struck whereby no species can dominate completely. Anemones behave in a similar way and soft corals sometimes leave noticeable trails where they have moved over hard coral killing the polyps as they go.



Anemone aggression

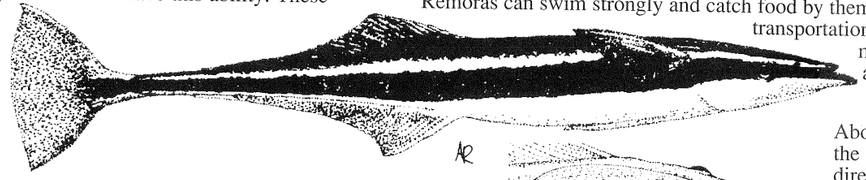
Good relations

The ability of the reef community to flourish in an impoverished environment is partly due to the remarkable relationships which exist between many of its members.

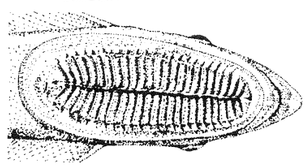


Coral formations make great homes for a huge variety of different animals, from the fish which lurk in their shadow to the borers which carve their homes out of the substance of their hosts. The larval **Christmas tree worm** settles on a piece of coral, perhaps where a polyp has been damaged and is unable to sting it and immediately secretes a small chalky tube. The coral grows up around the tube through which the worm feeds, excretes and breeds. It simply has to construct its tube at the same rate as the coral growth to prevent it from being sealed and can reach lengths of 50-60mm. A sharp spike at the entrance discourages fish from nipping at the feathery gills/feeding filters but the worm can contract rapidly into its tube sealing the entrance with a chalky plate. Christmas tree worms are very common in the massive porites coral boulders. The reasons for the variations in their colours are not known.

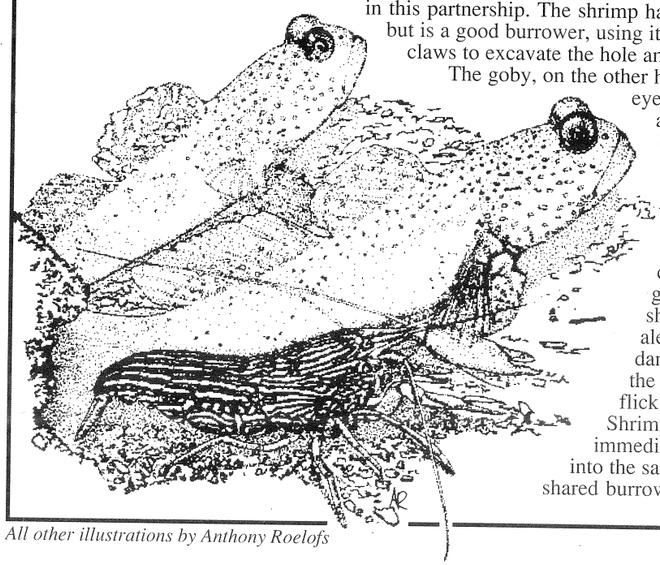
A variety of boring organisms such as worms, sponges, bivalves, algae and even particular hermit crabs make their homes in coral. In one study a 2.5kg block of coral was found to be honeycombed with more than a hundred species of polychaete worms alone. Some secrete a chemical which can dissolve the coral skeleton while others work their way in mechanically. Certain types of peanut worms grind away the coral with overlapping plates at the tip of their proboscis. It has been discovered, however, that the adults cannot penetrate a piece of coral - only the larvae have this ability. These tunnels and cracks also make good homes for another set of opportunistic tenants which cannot penetrate the coral themselves. The common sea urchin, *Echinometra mathaei*, with white-tipped spines, is often found in holes bored in corals.



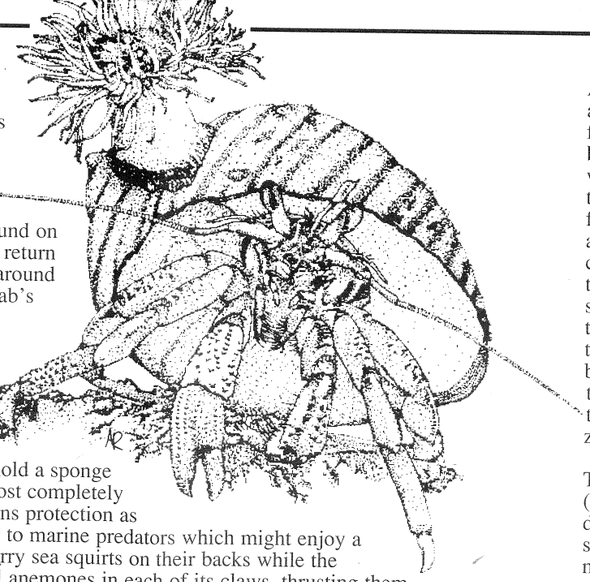
Coral growth is disrupted by various creatures - crabs, shrimps and barnacles - which make their home in it. For example wherever the female post-larval coral gall crab settles, usually at the end of a branch, the coral forms a 10-15mm wide gall-like chamber around it. A few small holes allow the much smaller male gall crabs to enter.



It is not unusual to find, on the sand bottom of a sheltered lagoon, a **goby** (or a pair) and an **alpheid shrimp** hovering around the entrance to a burrow. Each animal has its role in this partnership. The shrimp has poor vision but is a good burrower, using its heavy front claws to excavate the hole and keep it clear. The goby, on the other hand, has good eyesight and acts as a watch dog - but is not so good at the housework. The shrimp uses its long antennae to keep in constant contact with the goby. When the sharp-eyed and alert goby senses danger its warns the shrimp with a flick of its tail. Shrimp and goby immediately disappear into the safety of their shared burrow.



All other illustrations by Anthony Roelofs



Hermit crabs have abandoned normal crab shells for the stronger shells of molluscs and sometimes increase their defensive capabilities by carrying live anemones around on top of their shell homes. In return the anemones get to move around and are able to share the crab's meals. They can be found amongst coral in sheltered areas.

Other crabs have similar habits. The sponge crab has small back legs which it uses to hold a sponge on its back. The crab is almost completely covered and presumably gains protection as most sponges are distasteful to marine predators which might enjoy a feast of crab. Other crabs carry sea squirts on their backs while the boxer crab carries two small anemones in each of its claws, thrusting them at attackers. The decorator crab camouflages itself with a variety of sponges, algae and bits of debris held in place by tiny hooked bristles and glued with a sticky saliva. It can change its coat to match its surroundings.

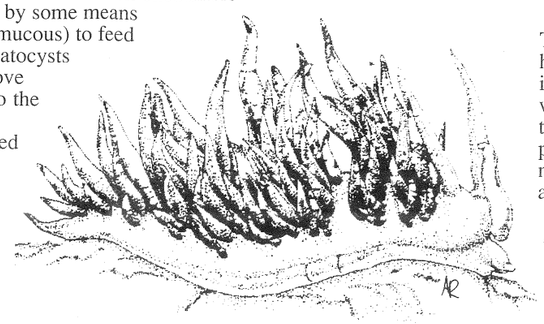
The dorsal fin of a **remora** has been modified to form a powerful sucker, the spines divided and flattened like a series of plates. When the fish wants to hitch a ride on a larger animal - shark, manta, whale, turtle (or even a boat or diver!) - it presses the fleshy oval margin of the sucker against the host's skin and by tilting the plates creates a vacuum. To free itself it merely swims forward which lowers the plates and breaks the vacuum. Remoras can swim strongly and catch food by themselves but use their suckers for easy transportation and access to scraps from their host's meals. They also remove parasites so, to a certain extent, pay for the ride.

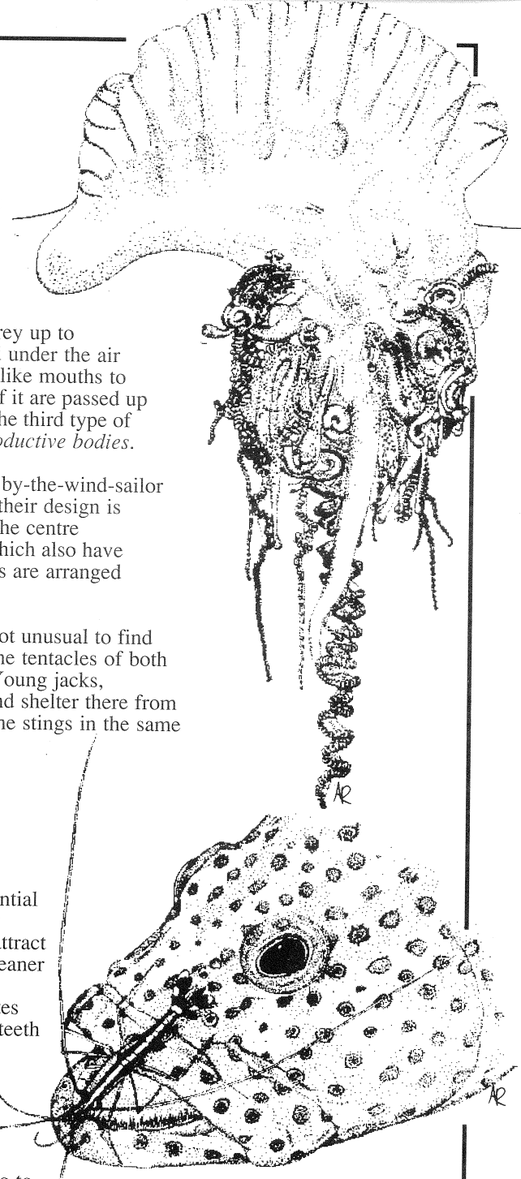
Aboriginal people sometimes tie a line to the tail of a remora and throw it in the direction of a turtle. The remora attaches itself to the turtle and the fishermen, by pulling backwards on the line, prevent it from breaking the vacuum as they haul the turtle in!

Nudibranchs, or sea slugs, are molluscs which have discarded their shells in the course of evolution. Most are extremely beautiful - and conspicuous - with bright colours and a variety of shapes but having no shells does not mean they are defenceless. Most have toxins in their skin and the bright colours probably function as a warning.

Many nudibranchs feed on sponges (from which they obtain their toxins) or ascidians (sea squirts) but members of the aeolid group eat corals (hard and soft), hydroids and anemones all of which have stinging structures called nematocysts which protect them from most predators and help them subdue prey. The nudibranchs, however, not only eat this unlikely food but also steal the nematocysts and use them for their own defence!

Nematocysts are small whiplike structures spring-loaded into cells which usually discharge when touched. When the nudibranch encounters an anemone, however, it is able by some means (perhaps by secreting a special mucous) to feed on its tentacles without the nematocysts being discharged. They then move through its digestive tract and to the tips of projections on its back, called cerata. Here they are stored and used to defend the nudibranch, firing into the mouths of any fish, etc., which are foolish enough to try to eat it. Look out for them among coral and encrusting invertebrates.





Although they look like single animals, some jellyfish are actually floating colonies. One of these is the **blue-bottle**, or Portuguese man-o'-war. Each individual - or zooid - in the colony is modified for a different function. Hanging below the blue air-filled bladder which keeps the colony afloat are long stinging tentacles, the *offensive zooids* which sting, capture and hold prey. These tentacles then contract, pulling the prey up to the *feeding zooids* which are situated under the air bladder. They all attach their sucker-like mouths to the prey and partly-digested pieces of it are passed up to the common base of the colony. The third type of zooids are the male and female *reproductive bodies*.

Two other jellyfish are colonial - the by-the-wind-sailor (*Velella*) and *Porpita pacifica* - but their design is different with one feeding mouth in the centre surrounded by reproductive zooids which also have mouths. The offensive tentacle zooids are arranged around the perimeter.

Although jellyfish prey on fish it is not unusual to find small fish living, unharmed, within the tentacles of both the colonial and the 'true' jellyfish. Young jacks, trevallies and pilot fish sometimes find shelter there from predators, apparently immune from the stings in the same way as anemone fish.

Most **shrimps** need to hide from potential predators, but certain species actually wave their white-tipped antennae to attract the attention of large fish. Like the cleaner wrasse (see *Tropical Topics* 10) they make their living by removing parasites and fungus from the scales, gills and teeth of a variety of fish which allow the little creatures immunity from attack.

Cleaner shrimps and fish have been seen attending not only to bony fish but also to mantas and stingrays, turtles and even crocodiles! They are very important to the health of reef populations; where they have been experimentally removed there have been definite declines in the health as well as abundance and diversity of fish in the local community.

The **pearl fish**, or messmate, (*Carapus*) is a long (15cm) thin fish which makes its home inside certain sea cucumbers, using the animal's anus as its front door! Once inside the cucumber it actually lives in the respiratory tree, a system of tubes through which water circulates. The fish spends its day at home but at night leaves the cucumber to search for food, returning tail-first. Unlike parasites the fish does not harm its host but neither does the cucumber seem to gain anything from its lodger.

A related fish lives inside bivalves and oysters where it sometimes becomes covered with mother-of-pearl secreted by its host.

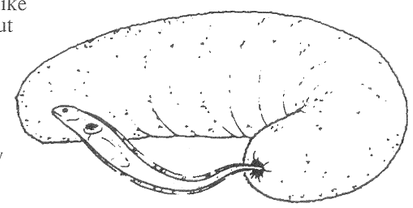


Illustration courtesy Queensland Museum

Questions & Answers

Q What is the latest on the crown-of-thorns?

A The starfish have recently been discovered on reefs at Lizard Island, and on Michaelmas and nearby reefs, about 30km north-east of Cairns. Although the numbers of animals are small the two previous outbreaks were first detected between Cooktown and Cairns before migrating south as the larvae were swept in the currents. If history is going to repeat itself, according to GBRMPA experts, they could herald an outbreak which would be expected to reach its peak about 1995-6.

No one is sure what causes these periodic outbreaks (in approximately 17-year cycles). They may well be natural and seem to follow El Nino years. They may even benefit the reefs by weeding out the fast-growing staghorn corals and giving the others a chance (see *Tropical Topics* 4). However, researchers are obviously concerned at the massive scale of the outbreaks and their relationship to increased nutrient levels in the water, caused by fertiliser run-off and sewage pollution. Crown-of-thorns larvae are produced in phenomenal numbers and since their major food source, phytoplankton, flourishes in high nutrient levels this may be the cause of the outbreaks.

GBRMPA has produced a crown-of-thorns survey sheet for visitors to the reef to record both the absence as well as the presence of the starfish. As regular visitors many of you are in an excellent position to help with their research and they would greatly appreciate your co-operation. Copies are available from Department of Environment and Heritage offices and from GBRMPA (addresses at the back of this newsletter).

Q Can you tell me why rifle birds are so named?

A Because they make a noise like a rifle shot!

Q What specific temperatures encourage estuarine crocodiles to climb from the water and sunbake?

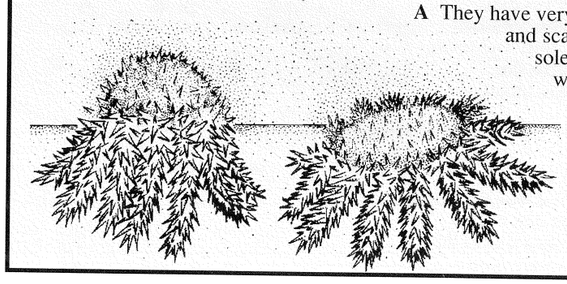
A When the water temperature drops below the air temperature.

Q Do birds migrate by day or by night?

A Both. They depend on various cues such as stars, the sun, the magnetic field or their sense of smell.

Q How do geckos run upside-down on ceilings?

A They have very fine claws and scales on the soles of their feet which are arranged to form suction cups.



Tourist talk

ENGLISH	GERMAN	JAPANESE	
relationship	beziehung	kankei	関係
parasite	parasit	kisei	
		doshokubutsu	寄生動植物
algae	algen	sou rui	藻類
photosynthesise	bildzusimmenstellung	kogosei	光合成
jellyfish	qualle	kurage	くらげ
anemone	anemone	iso ginchaku	いそぎんちゃく
stinging cells	stechende zellen	shi saibou	刺細胞
shrimp	garnele	ko ebi	小えび
coral	koralle	sango	珊瑚
host	gastgeber	shuku shu	宿主

Facts and stats

The name *zooxanthellae* (the x is pronounced as a z) means 'living in animals' (*zoos*) and 'yellowish-brown' (*xanthos*). The ending *ellae* indicates it is an algae.

Different light conditions affect growth rates and shapes of corals. Where sunlight is unlimited, plate species may take on convoluted forms which place polyps and zooxanthellae in shaded positions whereas in deeper or murkier water they grow in flat plates. If transferred to different conditions the corals have been observed to change their growth patterns accordingly. Corals without zooxanthellae, freed from the necessity of exposing them to sunlight, are able to grow in depths up to 5 000m, in caves and even in the cold waters of the Antarctic.

Animals produce waste ammonia. This is absorbed by zooxanthellae and converted into amino acids. These are used by the host coral or clam to build proteins or to provide energy for the muscles and pumping system.

Acetate (a sort of vinegar) is produced by corals, absorbed by zooxanthellae and used to produce fatty acids. The corals, in turn, use these to make energy-rich wax which is loaded into the larvae when they set off on their search for a suitable site for a new colony. Some is also exuded in the mucus which serves to clean the coral surface of sediments - and is, in turn, nibbled by fish.

Shoals of fish can be said to be living co-operatively, benefiting from the principle of safety in numbers.

Sharks and dolphins have been observed hunting co-operatively in 'packs', driving their prey into a confined area.

There is no end to the variations of relationships between reef animals. One female worm carries the male worm as a parasite inside her body!

Bioluminescence is a product of symbiotic bacteria living in the tissues of certain animals. When a biochemical substance, luciferase, which is made in the cells, reacts with oxygen in the presence of an enzyme the result is light. It is used by animals to signal and to attract prey, usually in deep dark waters.

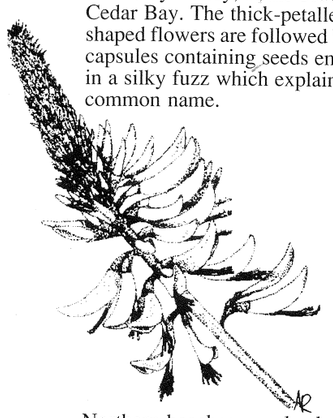
Huge numbers of bacteria flourish in the crevices of the reef feeding on waste products and dead organisms. They are in turn eaten by a variety of animals and therefore play a very important part in the retention and recycling of nutrients within the reef system. They capture vital amounts of nutrients from sea water, bringing them into the reef community.

Nature notes

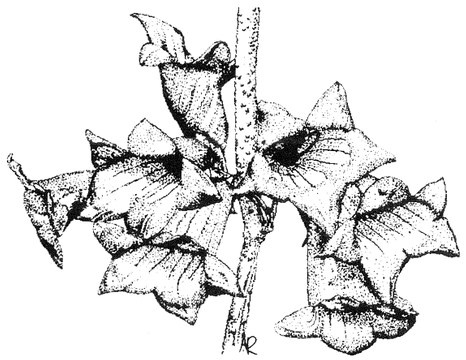
A diary of natural events creates a pleasing journal which grows richer with the passage of time. Watching for the recurrence of an event after noting it in a previous year, and trying to understand what could have caused changes in timing, is intriguing.

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. The editor will be delighted to hear your news. If you do not keep a nature diary perhaps this will inspire you to begin one. This column will be enriched by your contributions. Items published will be fully acknowledged.

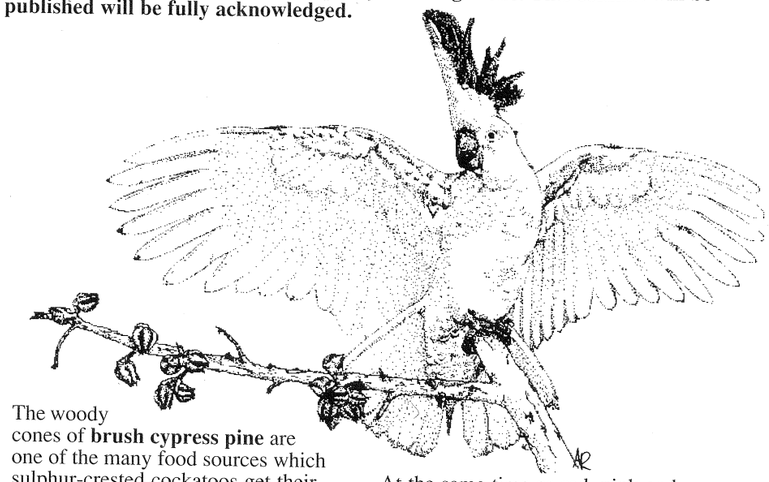
The vermilion-red flowers of **silk cotton trees** (*Bombax ceiba*) should be flaunting their colours along beaches and in forests this month. A tree in full bloom makes a memorable sight, whether growing close to the Gillies Highway, on the hills of Mowbray Valley, or the beaches of Cedar Bay. The thick-petalled, cup-shaped flowers are followed by woody capsules containing seeds embedded in a silky fuzz which explains its common name.



Northern beaches are also brightened by **coral trees** at this time of year. Their flame-orange flowers (above) spring from almost bare branches, welcoming pollinators with generous amounts of nectar. Coral trees (*Erythrina variegata*) are a member of the pea family.



Showy flowers of the **pink trumpet vine** (above) are sometimes abundant in August. This vine (*Tecomanthe hillii*) may twine around quite small trees in exposed sites, its flowers noticeable just a metre or two above ground. It is an adaptable plant, found at shrub height among exposed rocks, in melaleuca swamps and in quite rich rainforest.

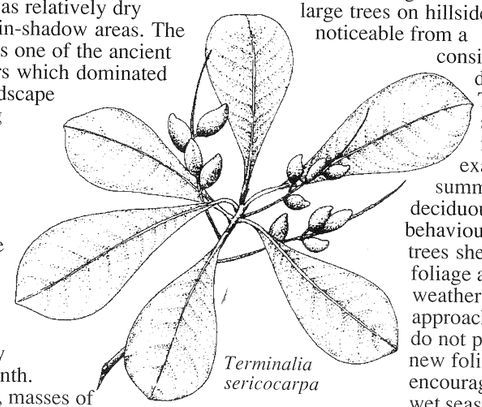


The woody cones of **brush cypress pine** are one of the many food sources which sulphur-crested cockatoos get their strong beaks into, gobbling the seeds before they scatter in the wind. This 'cypress' (*Callitris macleayana*) is a handsome tree occurring in northern New South Wales, patchily along the southern Queensland coast and as isolated populations in Far North Queensland. In the Wet Tropics this species occurs in marginal rainforest conditions such as relatively dry ridges and in rain-shadow areas. The genus *Callitris* is one of the ancient southern conifers which dominated much of the landscape before flowering plants evolved.

White bean (*Storckiella australiensis*) a tall-growing tree restricted to the Noah-Oliver Creek region failed to flower last year but may blossom this month. When flowering, masses of yellow pea-type flowers cover its crown making the tree quite conspicuous.

Another tree sending up bright heads of yellow blossom about now is the **golden bouquet tree** (*Deplanchea tetraphylla*) which is widespread in marginal rainforest conditions. The crowns of this tree are often made still more attractive by butterflies fluttering above the bunches of flowers.

At the same time as red, pink and yellow flowers herald the spring, **beach almonds** will be undergoing a version of tropical autumn, with last summer's leaves turning a beautiful red before they fall. Beach almonds (*Terminalia cattapa*) have a forest-growing relative, the damson (*T. sericocarpa*), which has similar habits. The red-orange colours of large trees on hillsides are noticeable from a considerable distance. This leaf-shedding is an example of summer-deciduous behaviour, where trees shed their foliage as dry weather approaches and do not put out new foliage until encouraged by wet season storms. However, in the case of the damson the deciduous period is very short, no more than a few weeks.



Terminalia sericocarpa

Both these *Terminalias* produce fly-attracting flowers, their strong odours generating nicknames like 'dead-horse tree'. The fruits which follow are popular with many bats and birds. Damson trees develop big buttresses and can reach magnificent proportions on creek banks and in well watered forests.