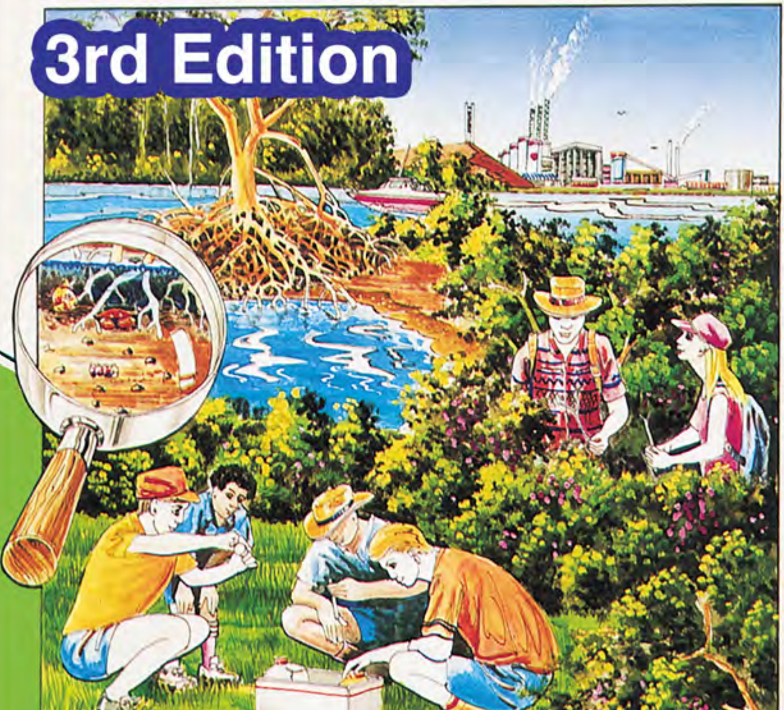
MANGROVES in Focus

3rd Edition



Moffatt Claridge Burnett

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Contents

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Illustration credits

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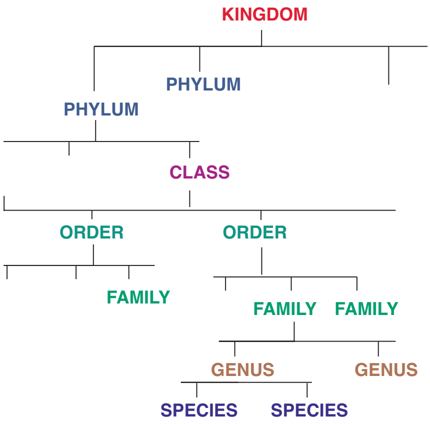
Chapter 1 Classification and biodiversity

by Bob Moffatt and Dave Claridge



Each KINGDOM is divided into a number of phyla.
Each PHYLUM is divided into a number of classes.
Each CLASS is divided into a number of orders.
Each ORDER is divided into a number of families.
Each FAMILY is divided into a number of genera.
Each GENUS is divided into a number of species.

Bob Moffatt

Figure 6.1 *Rhizophora stylosa*

Classification systems

There are a number of classification systems for marine organisms according to a range of characteristics. For example organisms that live on the sea floor are called benthic organisms and organisms that produce their own food are called autotrophs.

Mangroves are plants and fall into the group that makes their own food using the suns energy.

Levels of classification

The act of classification can be defined as the grouping of individuals so that all the individuals in one group have certain features or properties in common, Classifications should have predictive value, that is, they should tell us something about the object being named and its features.

Common names often seem easier to remember than scientific names, but they are not as precise. Not only can a common name refer to very different plants, conversely a single species can have more than one common name.

This can lead to confusion, and potentially to serious problems if people confuse weedy or poisonous species with harmless species. There are many types of classification, the oldest and simplest is a hierachy beginning with the kingdom, phylum, class, order, family, genus and species.

For example Figure 6.1 shows the red or spider mangrove which is classified as follows

Kingdom: Plantae *(makes its own food using the sun)*

Phylum: Tracheophyta *(has a water transport system)*

Class: Angiospermaes *(has flowers)*

Order: Myrtales

Family: Rhozophoraceae

Linnaean system

After the family level of classification, scientists end up with the two levels - genus and species.

This is called the scientific name as opposed to a common name that can vary from place to place.

Scientists use this system to describe the species accurately so there is no confusion.

So continuing on from our example from above, the stilted mangrove's scientific name is

Rhizophora stylosa

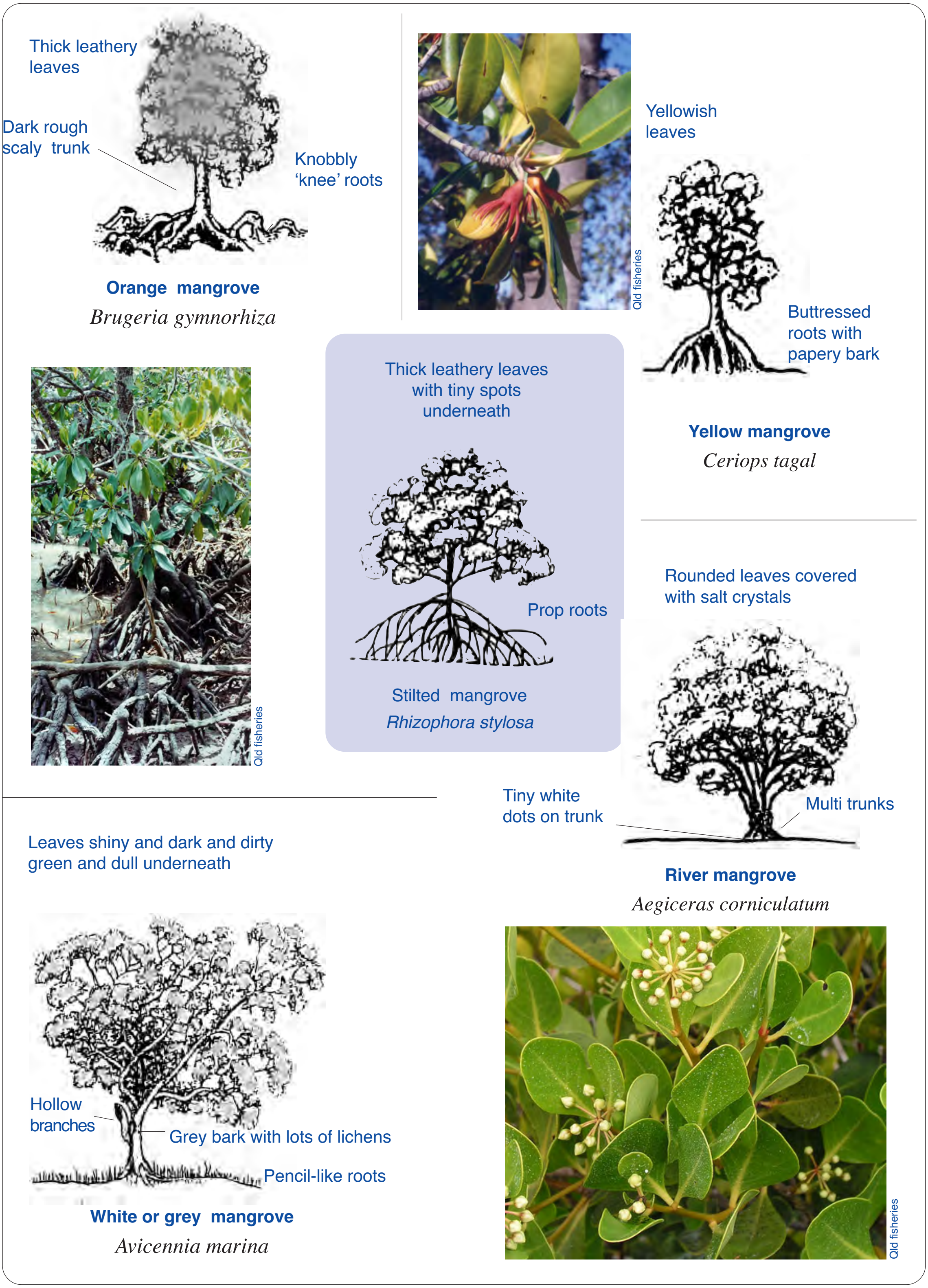
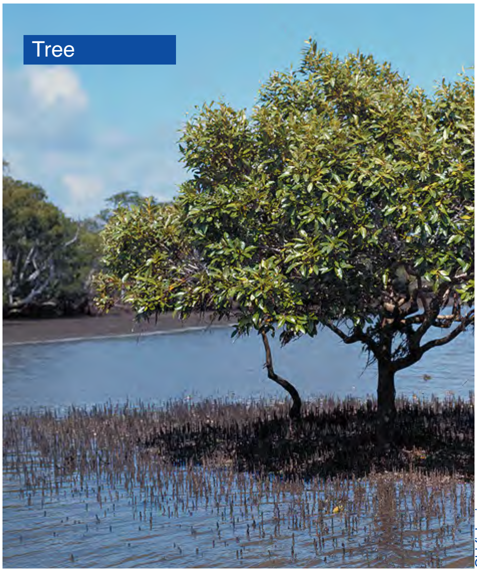


Figure 7.1 Other mangrove types
Qld Littoral Society



Qld fisheries

Qld fisheries

Figure 8.1 *Avicennia marina* leaves and fruit

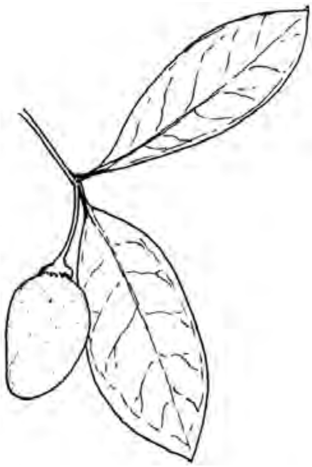


Figure 8.2 *Avicennia marina* leaves and fruit

Other examples

Avicennia marina

Family: Verbenacea

Common name: Grey mangrove or white mangrove

This is the most widespread mangrove in coastal Australia, being found in St Vincents and Spencer Gulfs in South Australia and as far south as Corner Inlet in Victoria — it is the only mangrove able to withstand the cooler temperatures.

It also is found in varied environments, from the upper reaches of tidal influence in rivers and creeks, where it is associated with *Aegiceras corniculatum*, to newly emerging mud banks which it pioneers along with *Rhizophora stylosa* or *Sonneratia alba*. It is also found in claypan hypersaline areas with *Ceriops tagal*.

Depending upon where it is growing, *Avicennia marina* may be a shrub less than 0.5 m tall to a large spreading tree up to 25 m. Leaf shape varies depending upon the environment. Leaves are opposite.

Upper surfaces are glossy green, with a pale grey below. Salt secreting glands are mostly on the underside.

Easily the most distinguishable characteristic of this species is the upright slender peg roots, called pneumatophores, which protrude through the mud from the lateral roots beneath the mud. These play a major role in aeration of the plant.

The orange-yellow flowers are small and appear in clusters in the leaf axils. Fruit are roughly shaped like a flattened egg about 3cm x 2cm; they are viviparous. A second species, *A. eucalypifolia*, occurs in northern Australia

Flowers: Spring

Fruits: Late summer/ autumn

Distribution: The most widespread species in Australia occurring in all states except Tasmania

Uses: A source of pollen for beekeepers, timber is light and strong and is used for boat building

Bruguiera gymnorrhiza

Family: Rhizophoracae

Common name: Orange mangrove or large leaf mangrove

This is a large tree which may attain a height of 10 to 18 m, with a dense leafy crown. It tends to prefer muddy/sandy areas which are covered only by spring tides. Buttresses may be present at the base of the trunk in mature trees.

The very large leaves are arranged in opposite pairs. The leaves are glossy green above and paler on the under surface. Single orange flowers are formed at the base of these leaves.

The cigar shaped fruit are viviparous. Apart from the leaf size the other distinguishing characteristic of *Bruguiera* is the knobbly 'knee root' similar to the pneumatophore of the grey mangrove.

There are four other species of *Bruguiera* found in northern Australia, all of which are smaller than *B. gymnorrhiza*. These are *B. exaristata, B. parviflora, B. sexangulata* and *B. cylindrica*. The differences are in the flowers and fruit.

Flowers: Spring

Fruits: Summer (Dec - Feb)

Distribution: Across northern and eastern Australia from NT to Richmond and Clarence rivers in NSW

Uses: Bark for tanning, the timber is very hard

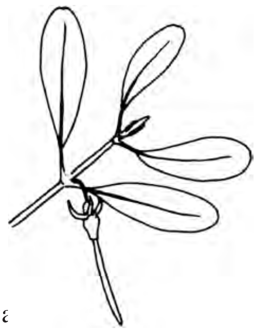
Bpb Moffatt

Figure 9.1 *Bruguiera gymnorrhiza*

Ceriops tagal

Family: Rhizophoraceae

Common name: Yellow mangrove, spurred mangrove



The genus *Ceriops* appears to be intolerant of lengthy fresh water flooding, but on the clayey soils which form extensive flats near the upper limits of mangrove shores, *Ceriops tagal* va *australis* is one of the most common species.

It occurs as a small shrub or a small tree from 5 to 10 m in height. From the air monospecific stands are clearly defined by the dense yellowish canopy.

Leaves are opposite, obovate in shapes with a notched tip and distinctly yellow-green in colour. The small white flowers appear in pairs at the base of the leaves. Fruit are viviparous. *Ceriops* is characterised by buttress roots.

The bark is pale and both the trunk and the buttresses are roughened by corky lenticels which are important for aeration of the plant.

Qld fisheries

Figure 9.2 *Bruguiera gymnorrhiza* flower and leaf

Biodiversity

"Biodiversity, the variety and abundance of life is an indication of the health of marine environments"

"The biodiversity of mangrove in many Australian States, is an indication of the health of marine environments."

Mangroves are found in intertidal areas on sheltered shorelines, and in the saline reaches of rivers and streams along major sections of the Australian coast as shown in Figure 10.1. The main factors which determine mangrove habitat are soil type of the intertidal region, climate and location.

The biodiversity of mangrove in many Australian States, is an indication of the health of marine environments.

Soil type of the intertidal region

Most mangroves are found on muddy silts carried by rivers and deposited in areas of low wave energy. These areas include estuaries, and places away from estuaries which are protected from strong wave action, and to which silt may be transported.

Generally speaking, the predominant substrates for mangroves are silts and mud, with fewer species in rocky or clay soils.

Climate and location

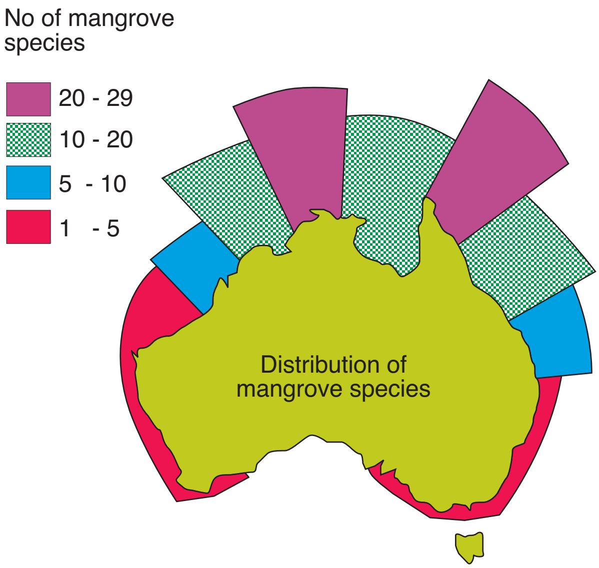
The climate of eastern Australia varies from temperate in the south to tropical in the north; the prevailing wind is from the south-east and is variable in the Gulf of Carpentaria. Mangrove communities are formed in areas protected from strong winds and resulting wave action. Thus, on the eastern coast, they are found within estuaries, on the western sides of offshore islands, and on the northern sides of headlands.

Qld fisheries

Figure 10.1 Extensive wetland/mangrove areas of the Gold Coast behind South Stradbroke Island.

Table 1 Common names of mangroves

Scientific name	Common name	Scientific name	Common name
Acanthus ilicifolius	Spikey or Holly-leaf mangrove	*Heritiera littoralis*	Looking glass mangrove
Aegialitis annulata	Club mangrove	*Hibiscus tiliaceus*	Swamp hibiscus
Aegiceras corniculatum	River mangrove	*Lumnitzera littorea*	Red flowered black mangrove
Avicennia eucalyptifolia	Eucalypt or smooth barked grey mangrove	*Lumnitzera racemosa*	White flowered black mangrove
Avicennia marina	White or Grey mangrove	*Nypa fruticans*	Mangrove palm or Nypa palm
Bruguiera cylindrica	Small fruited orange mangrove	*Osbornia octodonta*	Myrtle mangrove
Bruguiera exaristata	Rib fruited orange mangrove	*Pemphis acidula*	Pemphis
Bruguiera gymnorrhiza	Orange mangrove	*Rhizophora apiculata*	Tall stilted red mangrove
Bruguiera parviflora	Slender fruited orange mangrove	*Rhizophora mucronata*	Long fruited red mangrove
Camptostemon schultzii	Kapok mangrove	*Rhizophora stylosa*	Red or spider mangrove
Ceriops decandra	Flat leafed spurred mangrove	*Scyphiphora hydrophylacea*	Yamstick mangrove
Ceriops tagal	Yellow or spurred mangrove	*Sonneratia alba*	Pornupan or mangrove apple
Cynometra iripa	Wrinkle pod mangrove	*Sonneratia caseolaris*	
Excoecaria agallocha	Blind your eye or Milky mangrove	*Xylocarpus granatum*	Cannonball mangrove
		Xylocarpus mekongensis	Cedar mangrove



"Mangroves are found in intertidal areas on sheltered shorelines, and in the saline reaches of rivers and streams along the whole eastern Australian coast..."

"Most mangroves are found on muddy silts carried by rivers and deposited in areas of low wave energy..."

Figure 11.1 Approximate distribution of mangroves in Australia (after Hutchings and Recher, 1987)
Bob Moffatt

DAve Claridge

Figure 12.1 Hinchinbrook Channel, with Hinchinbrook Island in the background. The mangrove forest of this area totals over 100 square kilometres.

Bob Moffatt

Figure 12.2 Sheltered shorelines provide an ideal environment for mangroves to live.

Apart from mangrove communities in and around Darwin, the Gulf of Carpentaria and in estuaries sheltered by inshore sections of the Great Barrier Reef, the largest areas of mangroves are those which are protected by:

- Cape Melville
- Hinchinbrook Island
- Headlands of the Broadsound Area
- Curtis Island and Rodd's Peninsular
- Fraser Island
- The islands of Moreton Bay

Those sheltered shorelines contain roughly two-thirds of the total mangrove community of Australia as shown in the Figure 13.1 on the next page.

By far the greatest concentration of mangrove species is on the humid tropical north-eastern coast from about Mackay to Cape York. The large areas of mud flats in estuaries and deltas of this region are protected by the Great Barrier Reef. The number of species reduces as one travels southwards, until, in South Australia and Victoria, only one species is found.

All thirty species recorded in eastern Australia are found north of the Daintree River, which marks the southern limit of *Bruguiera cylindrica* and *Camptostemon schultzii*.

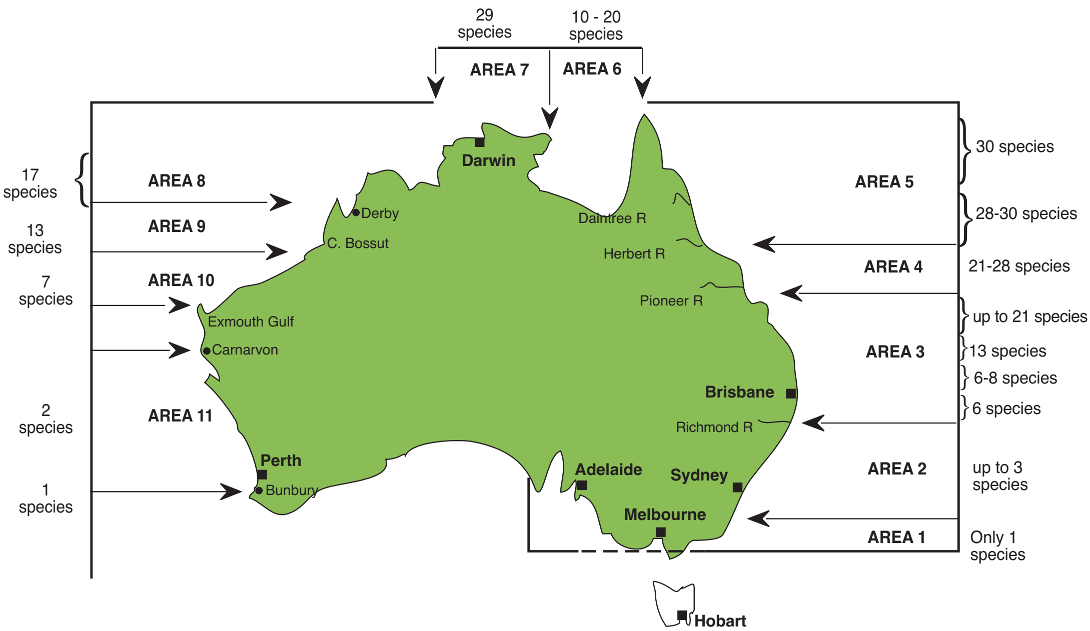
Further south, the Herbert and Seymour Rivers form a delta beyond which the *Ceriops decandra* and the mangrove palm *Nypa fruticans* do not extend; and several other species, e.g. *Sonneratia alba*, *Xylocarpus mekongensis* and *Lumnitzera littorea*, become rare. Is it coincidence that the mainland area adjacent to Hinchinbrook Island just happens to be the southern limit of true tropical lowland rainforest?

The Pioneer River in Queensland, forms another ecological boundary south of which a further eighteen species no longer occur. The Fraser Island/Great Sandy Straits areas form another limit beyond which a number of species become rare.

At least thirteen species are known in Sandy Straits, nine in Moreton Bay. Only *Avicennia marina*, *Aegiceras corniculatum* and *Excoecaria agallocha* are found south of the Richmond River. Mangrove vegetation in Victoria and South Australia is almost totally limited to stunted *Avicennia marina* and only in those areas which are mostly frost free. There are no mangroves in Tasmania.

Finally and by way of contrast, the different more arid climate patterns in Western Australia means that the number of estuaries and embayments is vastly reduced from that of the east coast.

Finally and by way of contrast, the different more arid climate patterns in Western Australia means that the number of estuaries and embayments is vastly reduced from that of the east coast. Except for the Kimberley coast there are four suitable habitats and fewer species than in comparable latitudes of the eastern coast.



Mangrove species	**Area as shown in figure below**										
Species name	I	2	3	4	5	6	7	8	9	10	11
Acanthus ilicifolius			x	x	x		x				
Aegialitis annulata			x	x	x	x	x	x	x	x	x
Aegiceras corniculatum		x	x	x	x	x	x	x	x	x	
Avicennia eucalyptifolia				x	x		x	x			
Avicennia marina	x	x	x	x	x	x	x	x	x	x	x
Bruguiera cylindrica				x	x		x				
Bruguiera exaristata				x	x	x	x	x	x	x	
Bruguiera gymnorrhiza			x	x	x	x	x				
Bruguiera parviflora				x	x	x	x	x			
Camptostemon schultzii					x	x	x	x	x		
Ceriops decandra					x		x				
Ceriops tagal var *australis*			x	x	x		x				
Ceriops tagal var *tagal*				x	x	x	x	x	x	x	
Cynometra iripa				x	x		x				
Excoecaria agallocha		x	x	x	x	x	x	x	x		
Heritiera littoralis			x	x	x						
Hibiscus tiliaceus			x	x	x	x	x				
Lumnitzera littorea				x	x	x	x				
Lumnitzera racemosa			x	x	x	x	x	x	x		
Nypa fruticans					x	x	x				
Osbornia octodonta			x	x	x	x	x	x	x	x	
Pemphis acidula			x	x	x	x	x	x	x		
Rhizophora apiculata				x	x	x	x				
Rhizophora mucronata				x	x	x	x				
Rhizophora stylosa			x	x	x	x	x	x	x	x	
Scyphiphora hydrophylacea				x	x			x			
Sonneratia alba				x	x	x	x	x	x		
Sonneratia caseolaris				x	x		x				
Xylocarpus granatum			x	x	x		x	x			
Xylocarpus mekongensis			x	x	x	x	x	x	x		

Figure 13.1 Mangrove distribution areas
Bob Moffatt and Dave Claridge


Qld Fisheries

Figure 14.1 At high tide, most mangrove roots are covered.


Bob Moffatt

Figure 14.2 Low tide sometimes reveals the mangrove mud and root system

Variety and abundance of life

A mangrove environment is like no other ecosystem on earth, except perhaps a closed tropical rainforest. In both cases the soils are generally poor, with most of the nutrients close to the surface. Because of this tree species are very shallow rooted. Many mangrove species are related to rainforest flora, and in some cases to tropical dry land vegetation.

However a mangrove forest is unique because no other ecosystem is there a mixing of marine and terrestrial fauna. With the exception of certain crustacea and a few fish species e.g. mudskippers, most marine animals are visitors, i.e. they spend only part of their life cycles in the mangroves. This is true also of terrestrial animals — most are visitors.

Mangrove mud

Mangroves are colonisers of new sand and mud bars, and, as the mangrove trees become more established in the area, wave energy is reduced and the fine particles carried by the water are allowed to settle. The result is a layer of dark sticky mud. More sediment is trapped by the various breathing roots of the different species of mangrove as is decaying leaf litter and seagrasses.

As sunlight reaches the developing mud, a vast mat of algae starts to grow which holds and stabilises the fine sediment. The algae is also an essential part of the food web within the mangroves, especially for the numerous species of snail that live in this environment.

In the mud, the most important group of organisms are the bacteria. The bacteria must overcome a number of difficulties living in this environment, the most pressing being the lack of oxygen in the mud. Once the oxygen is used in the decay of leaf litter on the surface, little penetrates deeper into the mud.

There are two reasons for this. Firstly, the spaces between the sediment particles are full of water and so the mud is waterlogged. Because oxygen diffuses at a very slow rate, it never penetrates more than a few centimetres below the surface of this waterlogged mud.

The second reason for the mud's lack of oxygen is the lack of soil structure. The sodium salts break down any crumbs or lumpy structures in the mud to form a homogeneous texture of cream-like consistency.

Bacteria on the surface of the mud will decay plant material in the presence of oxygen. However there is no oxygen deep in the mud and this is indicated by the black colour of the mud, often associated with the strong smell of rotten egg gas (hydrogen sulphide).

The hydrogen sulphide results from sulphate reducing bacteria, who in the absence of oxygen, use chemosynthesis to obtain energy.

This is achieved by breaking down the sulphates found in seawater and producing hydrogen sulphate as a waste product. Other bacteria release iron compounds as a result of their respiratory activity within the mud. This iron reacts with the hydrogen sulphide to produce the intense black iron sulphide which is a characteristic of the mangrove mud.

Living in the mud

Living on the surface of the mud, organisms are exposed to constantly changing conditions throughout the day, such as temperature, light intensity, pH, salinity, oxygen levels and hydrogen sulphide concentrations.

The concentration of hydrogen sulphide quickly reach a toxic level, fatal to most organisms. To live in these conditions, organisms must be well adapted and extremely tolerant.

Bacteria

The bacteria living on the surface of the mud have a ready food supply of plant material, which consists of large and complex molecules such as cellulose.

These bacteria have the ability to breakdown complex molecules and must have a ready supply of oxygen to be able to complete the reaction.

Microbes, leaf and seagrass litter

A range of flagellates and ciliates are also found on the surface, feeding on the bacteria and algae present (Figure 15.2). This is the beginning of a very diverse and complicated food web.

Figure 15.3 shows a mangroves growing in thick beds of mud bordering an estuary. It is the bacteria and microbial breakdown of this litter which is the beginning of many marine food chains.

Bob Moffatt

Figure 15.1 Seagrass beds like this one occur regularly on mud banks adjacent to mangroves.

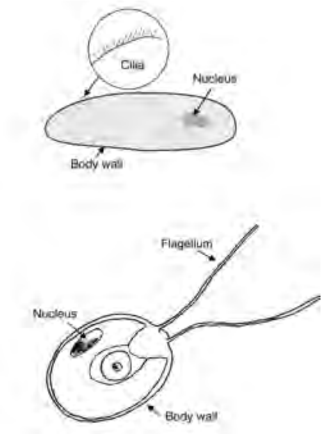


Figure 15.2 Microbes
Bob Moffatt

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Figure 15.3 Mangroves, mud and microbes

Figure 16.1 Peanut worm (Qld museum)

Figure 16.2 Yabby

Figure 16.3 Soldier crab

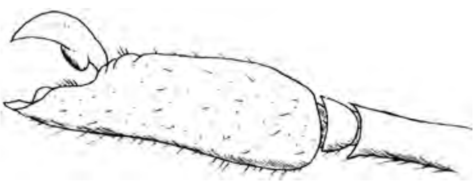


Figure 16.4 The large 'clicking' cheliped of the snapping prawn Alpheus sp, displaying the peg and socket arrangement (after Hale 1976).

Worms

A variety of worms can be found in the mangroves. The mangrove worm in Northern Australia provides Aboriginal and Torres Strait islanders a tasty meal and is found in rotting wood and mangrove logs.

The peanut worm is found buried in muddy creak banks and belongs to a small phylum Sipuncula. They can grow to 65 mm long sand have a tough leathery skin. They feed by grasping food with tentacles on their long throats.

Crabs

Yabbies (*Callianassa australiensis*) are found on banks in mangrove ecosystems as well as on intertidal sand flats. As well as being a vital link in the detrital food chain, they are popular among recreational anglers as a bait (see Figure 16.2).

Soldier crabs *(Mictyris longicarpus)*, occur on intertidal sandflats as well as on sandy banks within mangrove ecosystems (Figure 16.3).

A distinctive noise often heard in the mangroves is the clicking sound of the snapping shrimp (*Alpheus* sp., see Figure 16.4). The sound is produced by the snapping together of the finger sections of the enlarged chelae, which contain a unique peg and socket arrangement.

These shrimps live in the wetter regions of the mangrove, especially around the base of mangrove trees and under logs and rocks. Pillbugs (*Sphaeroma*) and other isopods live in the rotting logs and vegetation as do the various hoppers (*Amphipoda*) which are quite common in the mangrove environment.

Crabs are members of the phylum Arthropoda and belong to the class Crustacea. This is due to their exoskeleton which is quite hard and inflexible. The hard shell is unable to grow, so the crab will shed it by moulting.

This involves crawling out of the old shell and growing a new one. At this point of time the crab is vulnerable, especially to attack from predators. For this reason the five pairs of legs that they possess are well jointed and highly adapted to their environment. Crabs will use their legs to move, usually in a sideways motion, for speed and easy access into their burrows.

Crabs make up a rich part of the overall fauna of the unique mangrove environment. They are distributed throughout the environment, depending on the tidal movement, the structure of the mud and the salinity of the area.

Since most crabs have their own burrow in the mud, they seldom move far from its entrance. If the crab is removed from its immediate territory then it must either rob another crab of its burrow or excavate a new burrow.

Reproduction

When the female has just shed her shell and her new shell is still soft, the male produces a sperm packet which he deposits under one of her legs connecting to her egg pouch. This is a dangerous time for the crab as it is exposed to both dehydration and attack by one of the numerous mangrove predators.

The female then swims out to sea and releases her eggs with her partner's sperm into the plankton. The eggs are fertilised and quickly grow into a microscopic larval stage called a **zoe**. The zoe undergo several changes called a **metamorphosis** and change into a **megalopus** which is carried back towards the mangroves or salt marshes where they settle out of the plankton and take on their **juvenile** form (like tiny adults).

Juveniles feed off the rich life in the mangroves and grow quickly. They can also hide amongst the roots and logs in the mangrove habitat. They grow into adults and make burrows in the nursery areas to find a mate and start the cycle again (see Figure 17.2).

Without the protection of mangroves, the crabs would have no habitat to live and reproduce. This is why you often see bumper stickers which say - *no mangroves, no fish.*

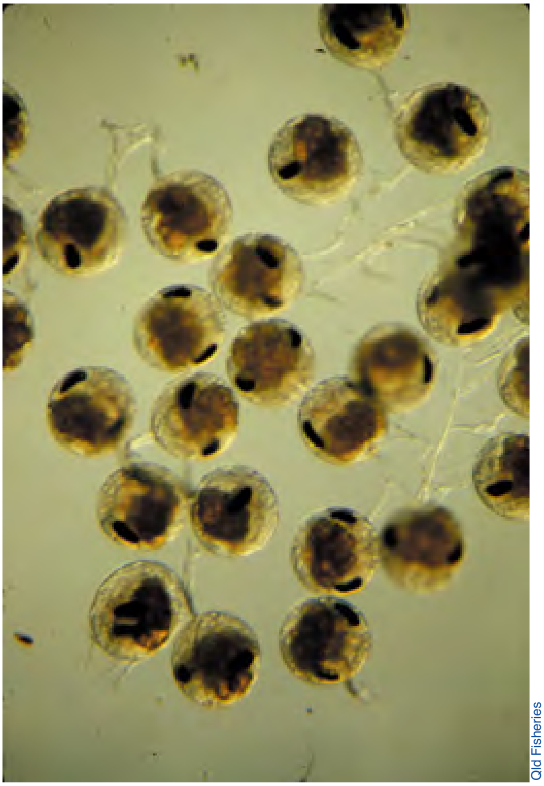


Figure 17.1 Crab eggs

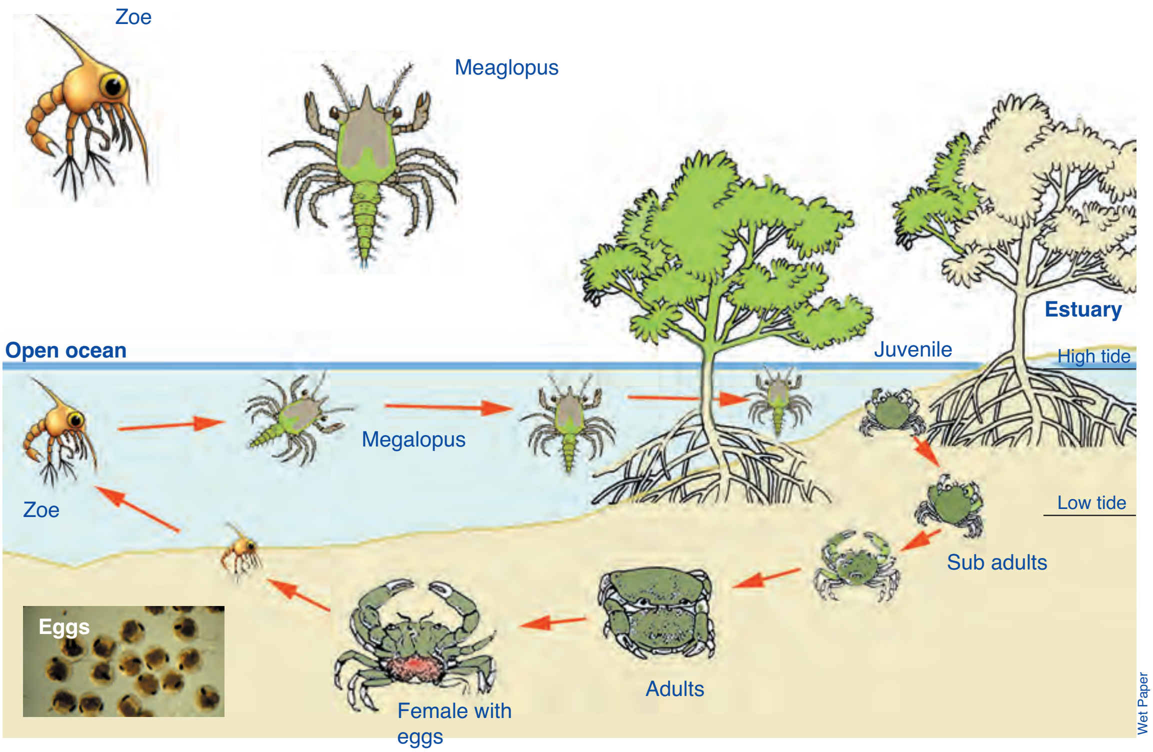


Figure 17.2 Crab life cycle (After Qld fisheries)

Crab identification

Hairy clawed crab Lump of mud in middle of each blue claw (actually hairs!), pale eyes, white stripes at front behind claws, orange nippers.	
Fiddler crab Has one large claw (almost as big as its body) and one tiny claw to feed with, there are three different types— one has a big white claw, another has a mainly orange claw with white nippers, while the third has a whitish upper nipper and an orange lower nipper on its big claw. Female fiddler crabs have two tiny equal-sized claws.	
Long eyed crab The crab is a brownish colour all over, has long eyes and hairy or fuzzy legs.	
Semaphore crab Adults have purple claws with whitish nippers, young ones have pink or orange claws with whitish nippers. They all have vertical white stripes on their front behind the claws. Legs and body dark.	
Mud crab Green, orange and brown colours on claws and shell. The largest crab you are likely to see during your visit. Will usually only be found in water. Sharpish 'spikes' around edge of shell. Last pair of legs flattened like paddles.	
Red fingered marsh crab Nippers always orange or red; adults have a green or bluish shell. Young ones can have a brown or black and green shell. Lots of tiny hairs on the legs.	
Hairy crab Orange-brown all over with no other colours. The top of the leg is shaggy/hairy and holds the mud. Ends of legs (feet) are very pointy and thin.	
Mottled shore crab Shell is dark with white speckles, mainly towards the bottom. Whitish claws with dark 'arms'.	
Red crab Red claws with pale tips to the nippers. Blackish body. Tiny hairs over legs and body. White spot on top of each eye. Textured fly screen-like surface on body behind claws (at the front).	
Red rock crab Reddish or orange-brown claws. Smooth, slightly flattened, dark body.	
Shore crab Yellow or orange claws on the adults with brown body. Brown claws and brown body on young ones. Usually four or six tiny pale spots on the back of its smooth shell.	

Jacoba Well EEC

Male and female

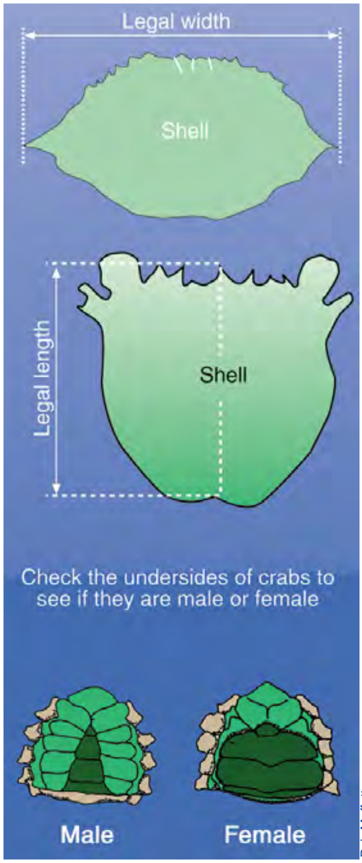
The differences between male and female crabs is shown in the Figure 19.1 Strict conservation guidelines apply to the taking of female crabs and their is legislation on the size limit on all crabs in all Australian States.

Other crabs

Fiddler crabs are often seen on mangrove flats at low tide (Figure 19.2). They communicate by means of a sequence of waves and gestures. Males have an oversized claw used in clashes of ritualised combat of courtship over a female.

The mud crab (*Scylla serrata*) are found along the banks of mangrove-lined rivers and creeks, remaining in their burrows until nightfall when they come out to feed on small fish, other crustaceans, molluscs and anything they can scavenge (Figure 19.3).

These crabs are highly cannibalistic in nature and when they moult other hard shelled crabs attack and devour them. Females can give rise to a million offspring which can grow to up to 3.5 kg with a shell width of 24cm.



Bob Moffatt

Figure 19.1 Male and female crab differences

Bob Moffatt

Figure 19.2 Fiddler crabs play a important role in mud ecology.

Qld Fisheries

Figure 19.3 Mud crab

"Strict conservation guidelines apply to the taking of female crabs and their is legislation on the size limit on all crabs in all Australian States."

Molluscs

Mangroves are fundamentally important in that they offer a habitat or shelter for other plants and animals. Small fish use the tangled roots of the mangrove forest as a protection from predators.

The incredible richness of the food chains in mangroves supports a large number of commercial and recreational fish species for at least a part of their life cycles. The most common permanent dwellers of the mangroves however are molluscs and crustacea.

Other species of molluscs found in mangrove ecosystems include:

- six different species of mud whelk
- several periwinkles, especially *Littorina scabra*
- a number of nerite shells
- balers and turrid shells
- oysters—the species differs according to locality
- various scallop species

Bpb Moffatt

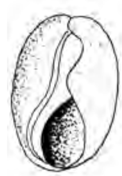
Figure 20.1 Mud whelks are common on mangrove banks throughout northern Australia.

John Burnett

Figure 20.2 Rock oysters adjacent to mangroves. Some oyster species can grow on the roots and trunks of mangroves .

Hercules mud whelk (*Pyrazus ebeninus*)

Telescope mud whelk (*Telescopium telescopium*)



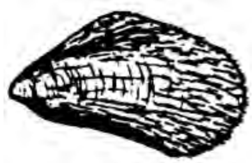
Bubble shell (*Quibulla* sp)

Black nerite shell (*Nerita lineata*)

Conniwink (*Bembecium nanum*)

Mangrove australwink (*Littoraria scabra*)

Fragile air breather (*Salinator salinator fragilis*)



Hairy mussel (*Trichomya hirsuta*))

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Midges

Mangroves do not have many species of insects compared with rainforests and other terrestrial woodland areas. Yet mangrove forests have acquired a reputation as being inhospitable places crawling with mosquitoes, sandflies and other biting midges.

However, the number of insects is mostly no more than in other damp forests. Midges only really become a 'pest' on still days when they are able to fly large distances inside the mangrove swamp. The end result has led to the belief that mangrove swamps have to be cleared to destroy the midge breeding grounds.

Humans have gone out of their way to control the mosquito/ sandfly/midge problem by clearing mangrove areas which are close to urban development.

In fact, disturbance of mangroves by clearing or dumping of rubbish may actually exacerbate the problem because it provides a more favourable habitat for noxious species of insect.

Life cycle of the midge

Midge eggs are laid in the upper part of the intertidal zone, with different species selecting different locations. The eggs hatch within days of laying and the tiny agile larvae emerge.

The larvae live in the soil water close to the surface, feeding on the organic detritus. Larvae respire through their skin. They grow rapidly taking six weeks to six months to reach maturity depending on the season and location. As the midge grows, the larvae will moult about three times.

After a final moult the larvae become pupae. The pupa has a thick rigid anterior half and a tapered flexible posterior half to allow mobility.

- At the front end are two small respiratory tubes through which they breathe air, remaining near the surface to do so.
- These pupa may drown if submerged for an extended amount of time of about 3-5 hours.
- The pupal stage varies in length from two days in summer to about two weeks in winter.

The adult midge emerges from the pupal case and mates shortly afterwards. The female of some species can lay a batch of eggs within a few days of pupating, using the reserves brought from the pupal stage as summarised in Figure 21.2.

This is a means of leaving progeny, even if she fails to find a blood meal, a requirement for the second egg batch and all subsequent layings.

Biting midges which attack humans away from the vicinity of their breeding site will usually show evidence of having taken at least one earlier blood meal and having laid again.

This previous blood meal was probably taken from birds or mammals found in or very close to the breeding grounds.

Bob Moffatt

Figure 21.1 Sand banks are traditional breeding grounds for midges

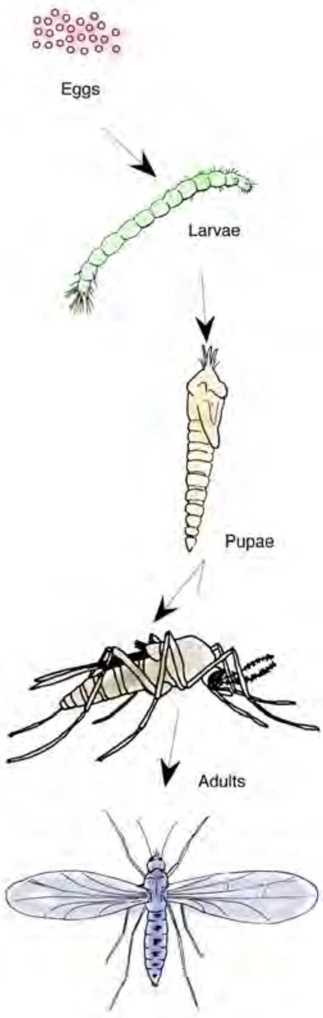


Figure 21.2 Life cycle of the midge (not to scale). Illustration in part courtesy Qld DPI Fisheries

Some facts about midges*

- The adult biting midges are about 1-2 mm long.
- Midges do not breed in grass, trees or in soil or sand in the garden. They only harbour in these areas.
- In overcast humid weather they are known to bite all day and night.
- For temporary relief have a hot bath.
- Anti itching creams or lotions from the chemist can be effective.
- Some medicated insect repellents give relief to the bite, if the person is not sensitive to the repellent.
- Natural repellents or lotions containing tea tree oil give some relief.
- For people who are sensitive to the bites, Vitamin B1 taken for a period over 30 days before exposure may reduce the reaction. (Check with a doctor before trying this treatment.)
- You should remember that biting midge numbers will increase around the time of the full and new moons. Therefore, it is advisable not to plan outdoor functions that coincide with these major midge emergence times.

* (These notes supplied courtesy of the Gold Coast City Council Department of Health).

"Infestations of midges are often blamed on the presence of mangroves but due to the conditions needed for breeding, this is a fallacy."

The very exacting conditions required for breeding, imposes restrictions on vertical range and the position of the breeding areas in the intertidal zone. The intertidal zone has three distinct areas—high, middle and low. If the larvae are in the high dry zone they will not survive, and if transported to the low zone then the larvae will probably drown. The best conditions for most species of midge are at the mean neap high tide level.

Restrictions in breeding may come about due to the special requirements of each species of midge. These requirements on the vertical range and position may include the nature of the substrate, the presence of certain flora and fauna, wave action or the variations in the salinity pattern in the area. The end result of imposing these restrictions is that very few breeding sites exist and they are intensely used.

Types of midges

Culicoides ornatus is a biting midge that has a geographical range from Maryborough, north around Australia and into Western Australia. It is an insect that finds mangroves essential for its survival. The larvae of this species require a very limited salinity range.

One value of the mangrove is that it reduces evaporation and so keeps salinity levels to a narrow range. On an exposed rocky shore for example where pools can heat up during the day, salinities can range greatly due to high evaporation rates and water levels.

Other factors also benefit the midge. For example mangroves provide shelter from strong winds, nectar and plant juices from flowers, and provide a perch for animals to rest on so providing prey for potential blood meals. Mangroves also reduce wave action and tidal currents in the mangrove thicket, assisting mud to settle and so helping the midge colony become established.

Culicoides subimmaoulatus is a common eastern Australian pest species which depends on burrowing crab (*Mictyris* sp.), a crab that live in sandy areas and adjacent to mangrove areas. This crab remains underground and feeds by driving a horizontal tunnel from a burrow it has dug in the sand. As it tunnels it throws up sand to the top of the shaft, and throws the spoils upward so that the tunnel is like a roofed trench. The midge larvae live in these trenches.

Mangroves act as inhibitors for both the crab and the midge larvae. The crabs and the midges are the early colonists on newly formed wave-free beaches but as the mangroves start to establish themselves the area, the spreading roots, pneumatophores, accumulated sediment and increased leaf litter prevent the crabs from digging their trenches.

Midge breeding decreases or stops completely in the developing mangrove forest. Midges may reappear in the mangroves if the mature forest is an open type, and the ground is not too muddy or covered with leaf litter.

Culicoides molestus is another east coast pest species. It lives in the intertidal zone or just above it, if there is clean sand and an open aspect. This species of midge cannot breed in the mangrove environment.

Other species of midge are also present throughout Australia but in the majority of cases the breeding site are in intertidal zones and do not require mangroves. There are also a number of fresh water breeding midges that are recognised pests, and when encountered are believed to have come from a mangrove environment.

The presence of mangroves in most cases is fortuitous for the midge, but are mangroves and midges totally related and can one justify the clearing of vast areas of mangroves just to rid an area of midges?

Midges as pests

As has been previously shown, midges require specific conditions in the intertidal zone for breeding.

These midges will cause regular infestations only within a limited distance from their breeding site. If the midge is allowed suitable damp conditions, such as a swamp, mangroves or a creek then they may be able to double the distance they can travel. Of all the pest midges, the greatest distance travelled is about 1.6 km (for *Culicoides ornatus*).

Mangroves are not, for the most part, the primary cause of any midge infestation, and may only be a convenient resting place or travel corridor for the midges. Mangroves play such a small role in the life cycle of most species of midge, that to destroy vast areas of mangrove for pest control is unreasonable and illogical.

Infestations of midges are often blamed on the presence of mangroves but due to the conditions needed for breeding, this is a fallacy. In fact it is the clearing of mangroves that often leads to the more suitable breeding conditions of certain species of midge, because it will open up an area, allow more light penetration and makes the intertidal zone more hospitable. In fact, with some of the east coast species, the planting of mangroves may be the best method of dealing with the midge problem.

Spiders

Spiders live in the leaves and on the branches and Leiper 1987 provides the following information about local species found in South East Queensland.

- In most species, the females are larger than the male and in most species, the female is known to eat the male.
- If a male lives on the same web as the female, he is used as a food locater. When he senses a catch on the web, he notifies the female then gets out of the way while she investigates and feeds. He feeds later.
- Most spiders have more than two eyes, most have six or eight eyes! These are used for forward vision and upward vision.
- Spiders can only see a few centimetres. They can sense a creature approaching because they have receptive hairs on their legs which detect air movement.
- Nocturnal spiders pull down their web after a night's trapping/hunting and then eat it. This provides protein in the diet.

Clearing of mangroves

Clearing of mangroves would not lesson the infestations by midges, in particular *Culicoides subimmaoulatus*, but would make it much worse.

The areas that have been altered due to clearing have been shown to have a very high larval density for this species.

The rapid development in canal estates, which often involves the demolition of large tracts of mangroves and the dredging of clean sand onto the reclaimed land, produces the perfect breeding grounds for *Culicoides molestus*.

Many people living on canals complain that nearby mangroves are causing infestations, when in fact the destruction of the mangrove exacerbates the problem.

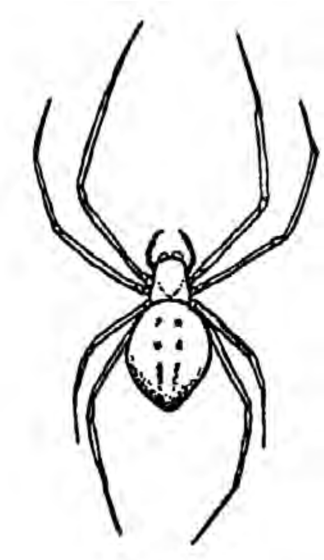


Figure 23.1 Golden orb spider
Jacobs Well EEC

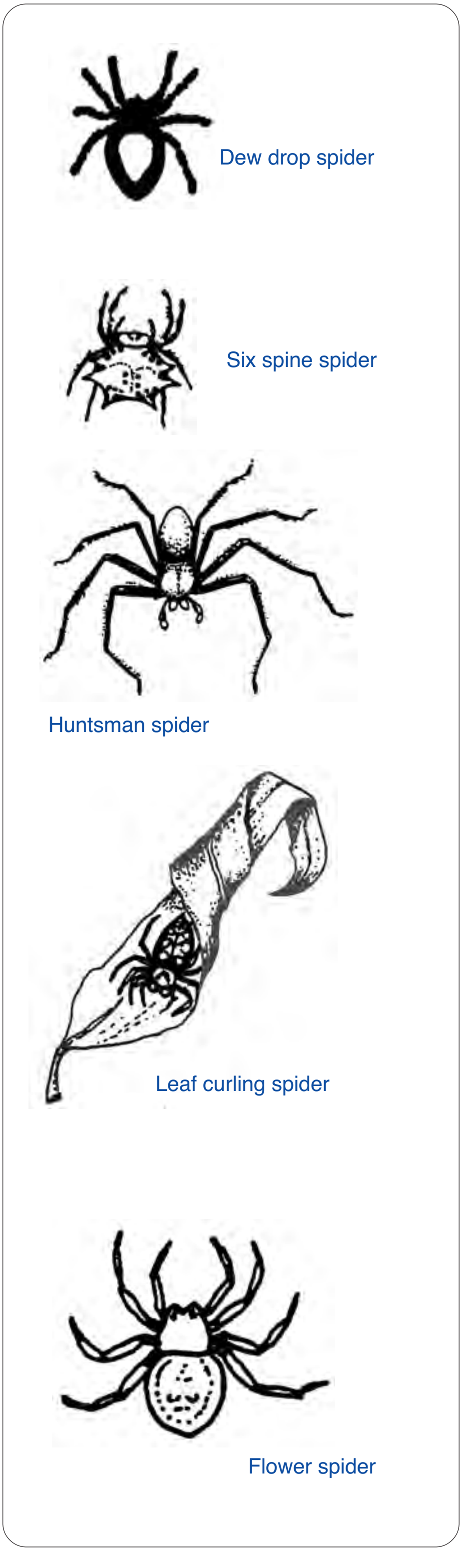


Figure 24.1 Common south east Queensland spiders
Glenn Leiper

Common south east Queensland spiders

Golden orb web spiders *Nephila* sp.

- Diurnal (day-feeding), building their web during the day (males are much smaller than the large female)
- They build a large, strong web—in the Pacific Islands it is used to make fishing nets
- Female wraps up tangled insects in silk, feeds on them then retires; male then moves in and feeds (female will eat male if given the chance)
- Female spins the web. Which also provides a home for dew drop spiders which the orb spider will chase away if they get in the way, especially while feeding
- The young are carried on the breeze after hatching. Upon landing, they make their own tiny web.

Dew drop spider *(Argyiodes anipodimus)*

- Silvery and small about 3 to 4 mm across and lives on the orb spider's web
- Will spin only occasional small amounts of silk on this larger web and cleans up after the orb spider, if allowed

Six spine spider *(Gasteracantha minax)*

- Nocturnal. The female is orange and black, male is black, about 8-9 mm in size who spins an orb web each night between low bushes (a wheel pattern) and removes web at daytime so that birds can not spot them and eat them, they eat their own web

Huntsman *(Isopoda* sp.)

- The juveniles (or young) are bright green to match their leafy habitat, the adult's body colour is black and hairy
- They protect their egg sacks, some even carry them on their backs, travel by the wind, natural home lies beneath the bark of trees and for food they depend on large insects including flies, moths and beetles
- They will bite humans and produce localised pain

Leaf curling spider *(Phonognatha graeffei)*

- Uses a leaf at the centre of its web to disguise its shelter, the leaf is dragged up on a silkline off the ground
- The spider hides in the leaf during the day then rebuilds its web at night, eggs are laid in folded leaves and hung some distance from the main web and food is mainly insects

Flower spider *(Diaea variabilis)*

- Found throughout eastern Australia and are common in flowers, gardens and in the field
- They use their colour for camouflage in the flowers , eats small insects and other spiders and are glossy white colour and is only about a centimetre across
- The first and second set of legs same length

Fish

Mangroves are the temporary habitats for fish population and are in the top three of the most productive ecosystems on earth.

For example the mudskipper, Figure 25.1, is an amphibious fish that can use its pectoral fins to walk on land and their tail to catapult into the air. They have the ability to breathe through their skin and the lining of their mouth and can dig into deep burrows to thermoregulate and avoid other predators.

For the recreational angler, this is a sample of species which may be caught in a typical mangrove estuary: bream, whiting (Figure 25.4), javelin fish, cod, luderick, small mulloway, threadfin salmon. Other species may include trevally, barramundi and mangrove jack (Figure 25.3).

Figure 25.1 Mudskipper

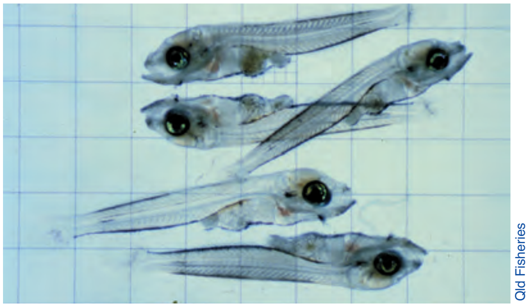


Figure 25.2 Immature whiting live in mangroves.

Figure 25.3 Mangrove Jack
NSW fisheries

Figure 25.4 Whiting
NSW fisheries

Fish reproduction

In most fish fertilization is external (Figure 25.1) with sperm and eggs fusing and dividing many times to form an embryo. In some cases (see box to right), males develop into females.

The larval stages contain the yolk sac and are known as fish fry. They feed on this yolk until they are able to find their own food, which is usually other plankton. In some fish species, it is often hard to tell the difference between males and females.

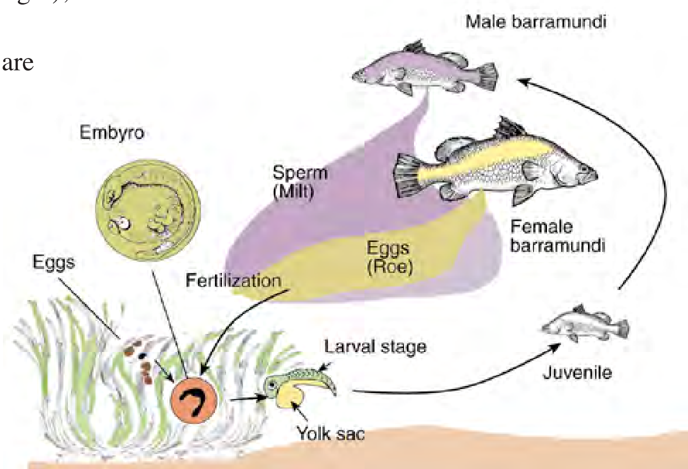


Figure 25.1 Fish reproduction in Barramundi
Bob Moffatt

Birds

Mangroves, together with associated wetlands, are important bird habitats. Both seabirds and terrestrial species are attracted to such areas.

Terrestrial species which feed on the mudflats, and in shallow water surrounding mangroves areas include, pelicans , egrets, stilts, spoonbills, ibis, jabiru, and heron. Such species may also roost in mangroves.

Waders also use the areas. Mudflats with nearby seagrass beds and intertidal banks tend to attract the greatest number of wading birds. Many of the waders are summer visitors which have migrated from the Northern Hemisphere's winter.

Some of these visitors include:

- golden plovers, a migrant from the Arctic regions.
- tattlers, migrants from Siberia or North America.
- curlews and godwits, migrants from eastern Asia.

Many of these species are listed in international conservation agreements with China and Japan.

Few terrestrial animals live in or visit the mangroves. Bats and flying foxes use the mangrove forest as a roosting site during the day, and range considerable distances over the surrounding countryside to feed at night. Occasionally wallabies and dingoes are seen at or near the landward fringe.

Mangrove forests of northern and eastern Australia (at least to south of Tropic of Capricorn) are home to the saltwater crocodile, *Crocodylus porosus*. Some species of land snakes and sea snakes are found in mangroves.

Observing birds

People who study birds are called ornithologists and birds have been watched and studied since recorded history. Perhaps our fascination for birds comes from our own inability to fly and we marvel at the skills birds have achieved to become the sole masters of the skies.

Birds can be observed with binoculars or by listening to the whole range of songs each makes. In the morning there is the dawn chorus where each bird gets up and makes its first call at a different time.

You can make a tape recording of this dawn chorus from first light (well before sunrise).

Bob Moffatt

Figure 26.1 Osprey

Activity

- Find a quiet place in the mangroves where a large number of crab holes are visible, sit on a log and observe. If you are quiet and make no sudden movements, the crabs will emerge from their holes and start to feed.
- Try to identify the different crab species and note the different feeding methods they use.

  What are the different crabs feeding on?

  How do different crabs move?

  Describe the various ways by which the crabs use their claws.

  What do fiddler crabs do with their large claws?

The saltwater crocodile

No discussion on mangroves would be complete without some mention of this, the most dangerous predator in Australia. An adult saltwater or estuarine crocodile, *Crocodylus porosus*, has no predators, even though juveniles may fall prey to birds, large fish, goannas and even feral pigs.

Growing up to 6 metres long they range across northern Australia from the Kimberleys to the Queensland coast well south of the Tropic of Capricorn. Their diet includes birds, fish, mammals, and occasionally humans. In this they differ from their smaller freshwater cousins, *Crocodylus johnstonii*, which are fish eaters.

After 1945 crocodiles were hunted extensively for their skins right across northern Australia, in some areas almost to extinction. However since protection of the species was introduced - (Western Australia, in 1969, Northern Territory, in 1971 and Queensland in 1974) - numbers have increased dramatically throughout their range and even into marginal areas as far south as the Boyne and Mary Rivers.

Since nesting occurs during the wet season in December-March, crocodiles have difficulties maintaining the temperatures needed in the nesting mounds during the two and a half to three month incubation period (temperatures below 30^0C produces all females, above 32^0C all male, below 28^0C and above 34^0C are lethal to the eggs). In addition, a very dry spell between August and December greatly reduces the nesting effort.

If you add all this to the extremely high mortality rate among crocodiles, it is easy to see why crocodile numbers will never be high at the limit of their range however some culling will probably become necessary within a few years in areas around northern urban centres.

Terrestrial animals

Few terrestrial animals live in or visit the mangroves. Bats and flying foxes use the mangrove forest as a roosting site during the day, and occasionally wallabies and dingoes are seen at or near the landward fringe.

Bob Moffatt

Figure 27.1 Saltwater crocodile in the Kimberley

Bob Moffatt

Figure 27.2 Freshwater crocodile

Lab exercise 1.1 Mangrove microbes

by John Burnett

Aim

To examine various microorganisms found in mangrove mud under a microscope

You will need

- microscope
- microscope slide and cover slips
- jar of mangrove mud

What to do

Read the boxed section on the next page first.

Part A: Growing the microbes

1. Take a sample of mud from one of the stagnant pools among the mangroves and put in a jar with 20 - 30 mm seawater covering it as shown in Figure 28.1.
2. In order to obtain a good culture, place the jar in the sunlight for the light requiring microbes to migrate to the surface and to repopulate the surface. If the jar is kept in the dark for too long, the various flagellates and cilliates will consume the cyanbacteria and bacteria.

   The culture is very hardy, and tolerant of salinity and temperature variations. You can replace the water lost through evaporation with distilled water (not chlorinated).
3. To regenerate the culture and in particular the sulphur cycle, replace the sea water every six to seven days.

Part B: Microbe examination

Examine the various microorganisms under a microscope following the following procedures.

1. Place a small sample of culture onto a cavity microscope slide.
2. Add a drop of sea water and spread out the sample.
3. Place a cover slip on the top and observe, starting with low power.

   When you have found any organisms of interest, increase the magnification. You will need to adjust the light as too much light will prevent you seeing transparent organisms.

Analysing your results

1. Sketch what you observe through the microscope using simple line drawings or take digital photographs
2. Identify organisms you find using reference books or the internet.
3. Discuss the role microbes play in balancing the marine environment
4. Explain why microbes survive their hostile environment.
5. Summarise your findings in a powerpoint presentation.

John Burnett

Figure 28.1 Examining mangrove mud

Read this

Microbes

A major group of organisms found in the mangroves are the various microbes. They include the cyanbacteria, large sulphur bacteria, diatoms, flagellates, ciliates, nematode worms and small crustaceans.

Microbes are most dominant when the conditions are the most difficult and where the large organisms cannot survive.

They are opportunists and will colonize a new area very quickly. They can live in areas where there is no oxygen and some can even use the poisonous hydrogen sulphide gas (rotten egg gas) as a means of energy supply.

Types of microbes

Photosynthetic microbes (use light) and live on the surface of the mud, or under the mud, feeding on the vast amount of organic material. Chemosynthetic microbes manufacture their own carbohydrates, using chemicals in the mud as an energy source.

Ciliates

Ciliates are microscopic unicellular organisms that have many hair-like cilia covering their outer surface. These cilia all move in a uniform motion to allow locomotion and to obtain food.

Flagellates

Flagellates are microscopic free-moving organisms who move around rapidly waving a flagella.

John Burnett

Figure 29.1 Jar of mangrove mud

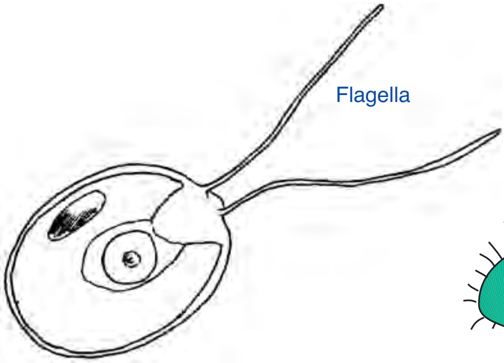


Figure 29.2 Flagellate
John Burnett

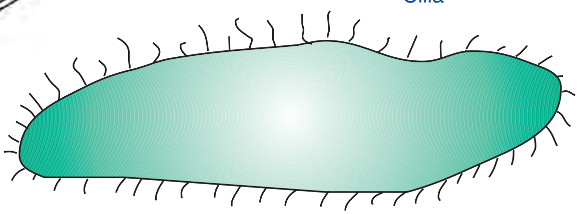


Figure 29.3 Ciliate
Bob Moffatt

Lab exercise 1.2 Scat analysis

Brian Brock

The birds and other mammals that frequent the mangrove environment have a varied diet, ranging from sea grasses, shellfish, crabs and fish to mangoes and pawpaw when birds raid gardens and orchards.

Note

The chemicals* used in this experiment are very strong and correct safety procedure should be followed.

Take care with sulphuric acid, Millon‘s reagent and nitric acid.

Personal hygiene and safety

Make sure you wash hands and wear gloves when collecting scat samples

Aim

To analyse the scats (droppings) of birds found in mangrove leaf litter or undergrowth to determine their diet.

You will need

- microscope
- microscopeslides and cover slips
- iodine solution
- concentrated sulphuric acid*
- Millon’s reagent*
- concentrated nitric acid*
- ammonium molybdate
- methylene blue

What to do

In the field

1. In the field collect samples of bird scats from the mud, trees and even from the boardwalks in areas open for public access.
2. If there is a bird colony in your study area, collect samples from under the colony for later analysis, or set up fixed square sheets of plastic or material to collect the scats.
3. Record your results in a table.

Figure 30.1 Ibis in trees

In the laboratory

Examine a wet slide of the scat sample for traces of fibre, fish bone and scales.

Starch test

- Add a drop of iodine solution to the sample. Examine under the microscope.
  If it turns blue-black then starch is present.

Cellulose test

- Place some of the scat onto a clean slide, add a drop of concentrated sulphuric acid and then add a drop of iodine solution.
  Blue-black indicates cellulose is present.

Protein test

- Place a small sample of the scat in a test tube, add three drops of Millon's reagent and gently heat.
  A brick red colour indicates protein is present.

Phosphate test

- Add ten drops of water to be tested into a test tube. Now acidify with 2 drops of concentrated nitric acid. Add one spatula of ammonium molybdate, stir and then warm gently.
  A canary yellow precipitate indicates the presence of phosphate.

Seeds

- Carefully examine the bird scats and remove any seeds you observe.
  Try to identify the plant to which the seeds belong.
- Place a sample of the bird scat onto a microscope slide, spread over the slide and stain with methylene blue stain. Examine under the microscope for pollen grains.
  Sketch them for later identification.

Analysing your results

1. Describe conclusions you could make about the diets of the birds that frequent the mangroves.
2. Suggest the source of the different bird's food supply.
3. Identify the main source of food for the birds from your investigations.
4. Summarise your findings in a powerpoint presentation

Data table

Test	Colour	Present	Absent
Starch			
Cellulose			
Protein			

Figure 31.1 Sample data table

Figure 31.2 Osprey
Kerry Kitzelman

Project 1.1 Fish and mangroves

by John Burnett

You will need

- Home made equipment as shown in Figure 32.1

What to do

- Place some bread into a glass bottle.
- Tie a piece of cord around the neck of the bottle and the other end around a tree.
- Place the bottle into a permanent body of water, gently filling it with water.

  Leave for a while, then remove the bottle quickly from the water to retrieve any fish.

  Try a range of different baits (pieces of fish, prawns, fish berley) and locations (in the shade, shallow water, and deep water).

  Make sure you return the fish when you have finished.

Conservation tip

Remember to be very careful when handling crabs and fish or anything you catch for scientific purposes.

Always return them carefully to the place you collected them from.

Analyse your results

1. Describe your experimental methods and evaluate their effectiveness.
2. Compare the effectiveness of the different types of baits you used.
3. Identify, photograph and draw the type of fish that inhabit local mangroves
4. Describe your experimental setup and summarise your findings in a powerpoint presentation.

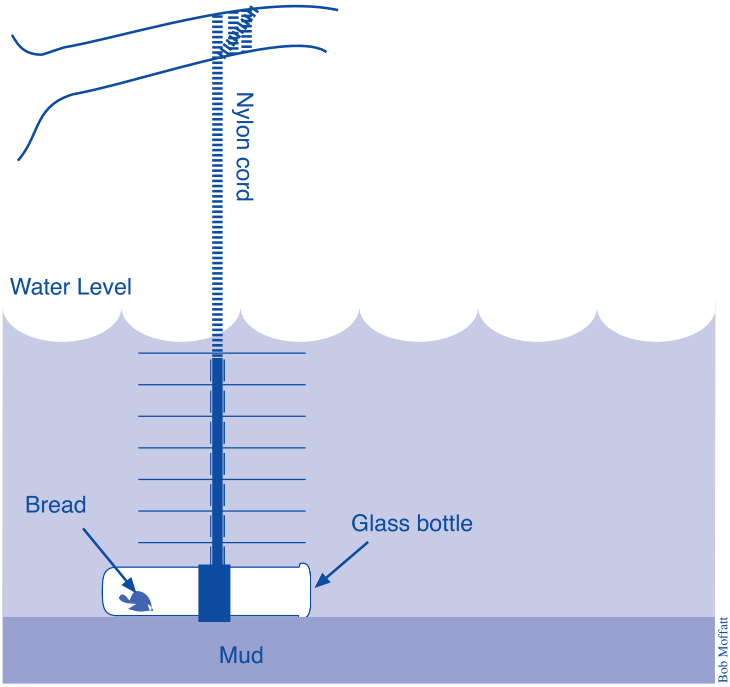


Figure 32.1 Experimental set up

Project 1.2 Organisms that live in the mud

by John Burnett

You will need

- Collection sieve
- Yabbie pump
- Microscope and slides
- Petri dish

What to do

- Use a yabby pump to collect a sample of mud and place it on a sieve.
- Wash the sample carefully with sea water and examine for the different organisms (e.g. worms, midge larvae, small crustaceans) that may be found in the mud.

  You may need a microscope to identify smaller organisms.

Analyse your results

1. Identify and draw the different organisms, and determine the numbers of each species.
2. Describe adaptations of animals to their habitat.
3. Describe and evaluate your experimental methods.
4. Describe the habitat of a yabby. Illustrate your answer with a drawing of its burrow.

Qld Fisheries

Figure 33.1 Yabby

Qld Fisheries

Figure 33.2 Yabby pump

Figure 34.1 Copepod and phytoplankton
Can you take a better photograph?

Project 1.3 Mangroves and plankton

by Bob Moffatt, Bernard Cooke, Tony Edwardson, Jack Marsh, David Tulip and staff Jacobs Well EEC.

You will need

- Plankton sample
- Microscope and slides
- Petri dish
- Identification chart or internet

What to do

- Collect a sample of plankton and place it on a microscope slide.
- Use the illustrations on the next page to identify adult or immature stages.

Analyse your results

1. Identify the different organisms, and determine the numbers of each species. Draw illustrations like the ones in the figure on the next page.
   Use the internet images to find other example of plankton that might live with Australian mangroves.
2. Present an argument for how mangroves are linked to the sea.
   Refer to Figure 34.2 to justify your argument.

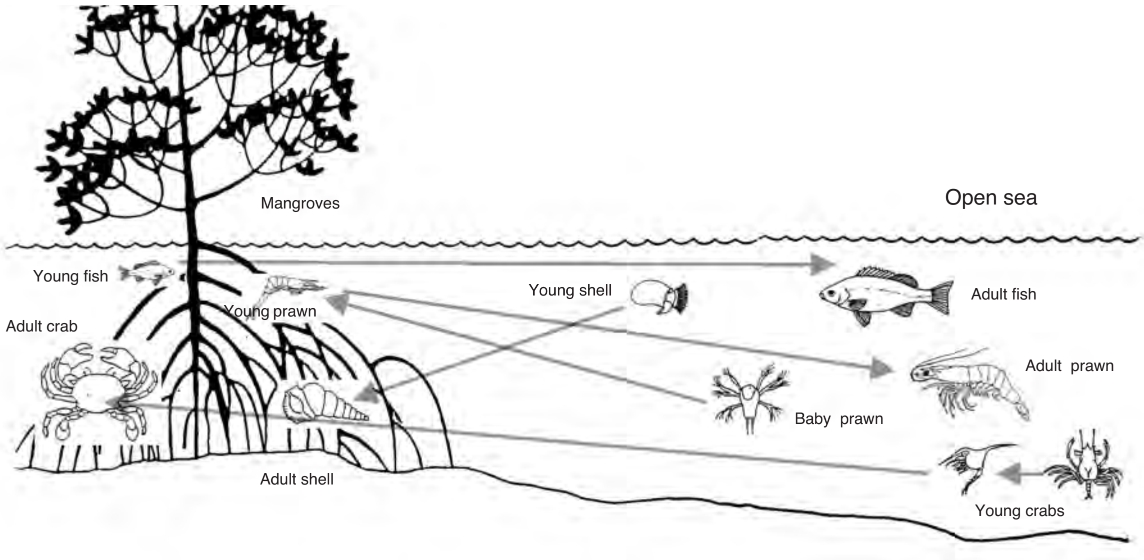


Figure 34.2 Sample mangrove open sea interactions

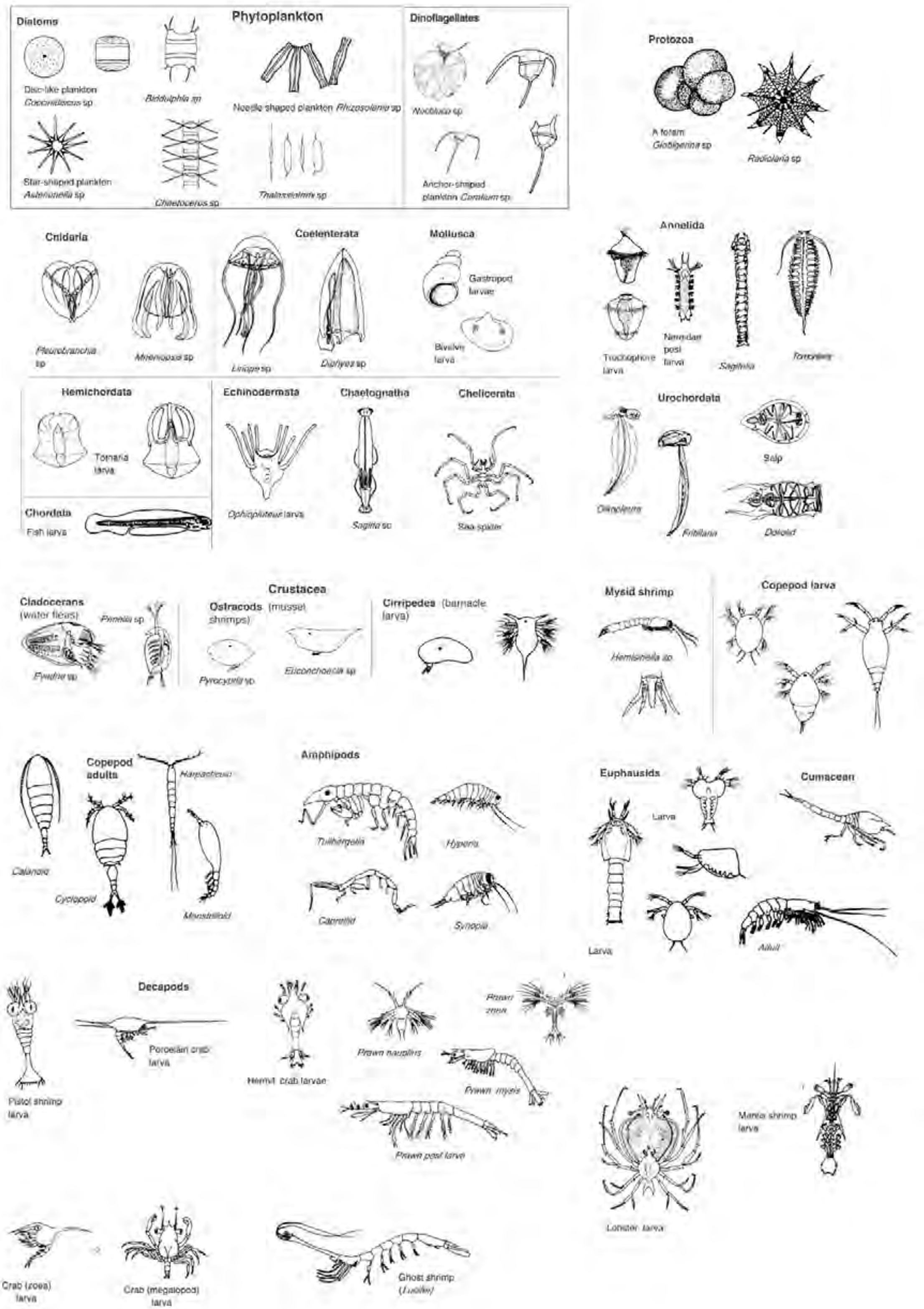


Figure 35.1 Plankton of Moreton Bay Qld

The illustrations that follow are from *Plankton of Moreton Bay* by Bernard Cooke, Tony Edwardson, Jack Marsh and David Tulip. (Copyright - reproduced here with permission)

Project 1.4 Mangrove identification

Analyse your results

Use the keys on the next five pages to identify mangroves in your local area. *See glossary for explanation of terms.*

Lear and Turner (Scientific key)

In order to use the key start with number 1, select which of the two given statements best describes the species you wish to identify, follow the numbers carefully, repeating as necessary until the identification is complete.

Characteristic	Genus / species
1. palm frond	*Nypa fruticans*
not a palm	go to 2
2. leaf blades usually>120 mm long	go to 3
leaves usually<120 mm long	go to 4
3. prop roots/knee roots present	go to 5
no prop or knee roots	go to 6
4. compound leaves	go to 7
simple leaves	go to 8
5. aerial/prop roots from branches	*Rhizophora* sp.
no prop roots from branches	*Bruguiera* sp.
6. buttresses present (large)	*Heritiera littoralis*
buttresses absent	*Camptostemon schultzii*
7. symmetrical leaflets	*Xylocarpus* sp.
asymmetrical leaflets	*Cynometra iripa*
8. leaves opposite	go to 9
leaves alternate	go to 14
9. underside of leaves grey	*Avicennia* sp.
not grey	go to 10
10.stipules present	*Scyphiphora hydrophylacea*
no stipules	go to 11
11.gland at base of leaf stalk	*Sonneratia* sp.
leaf stalk lacks gland	go to 12
12.finely toothed upper leaf margin	*Osbornia octodonta*
spiney teeth on leaf margin	*Acanthus ilicifolius*
leaf margin complete	go to 13
13.terminal shoots spearhead shaped	*Ceriops* sp.
not so	*Bruguiera* sp.
14.leaf underside grey	*Camptostemon schultzii*
not grey	go to 15
15.white latex(milky sap) present	*Excoecaria agallocha*
no latex present	go to 16
16.gland at leaf apex	*Lumnitzera* sp.
no gland at leaf apex	go to 17
17.petiole sheathing of stem	*Aegialitis annulata*
stem not sheathed	*Aegiceras corniculatum*

Figure 36.1 This key is based on one developed by Lear and Turner (1977). It is reproduced with permission of the University of Qld Press.

Morphology key

These keys are based on visual identification of plants. This one is based on an original exercise by staff at Ingham State High School. Use the information in Figure 37.1 to assist.

	Characteristic	**Genus / species**
1.	Stilt roots and/or knee roots present	go to 2
	Stilt roots and/or knee roots absent	go to 3
2.	Aerial prop roots	*Rhizophora* sp.
	No aerial prop roots	*Bruguiera* sp.
3.	Leaves compound	go to 4
	Leaves simple	go to 5
4.	Mid rib vein central	*Xylocarpus* sp.
	Mid rib vein slightly off centre	*Cynometra iripa*
5.	Leaves opposite	go to 6
	Leaves alternate	go to 10
6.	Underside of leaf grey	*Avicennia* sp.
	Underside of leaf not grey	go to 7
7.	Interpetiolar stipules present	*Scyphiphora* sp.
	Interpetiolar stipules absent	go to 8
8.	Leaf stalk with two glands at base	*Sonneratia* sp.
	Leaf stalk without glands at base	go to 9
9.	Leaf margin finely toothed in upper half	*Osbornia* sp.
	Leaf margin with spiny teeth	*Acanthus* sp.
	Leaf margins entire	*Ceriops* sp.
10.	Leaf underside grey	go to 11
	Leaf underside not grey	go to 12
11.	Leaf tip acuminate	*Heritiera* sp.
	Leaf tip emarginate	*Camptostemon* sp.
12	Latex (milky sap) present	*Excoecaria* sp.
	No latex	go to 13
13.	Gland at leaf apex	*Lumnitzera* sp.
	No gland at apex	go to 14
14.	Leaf stalk stem sheathed	*Aegialitis* sp.
	Leaf stalk not sheathed	*Aegiceras* sp.

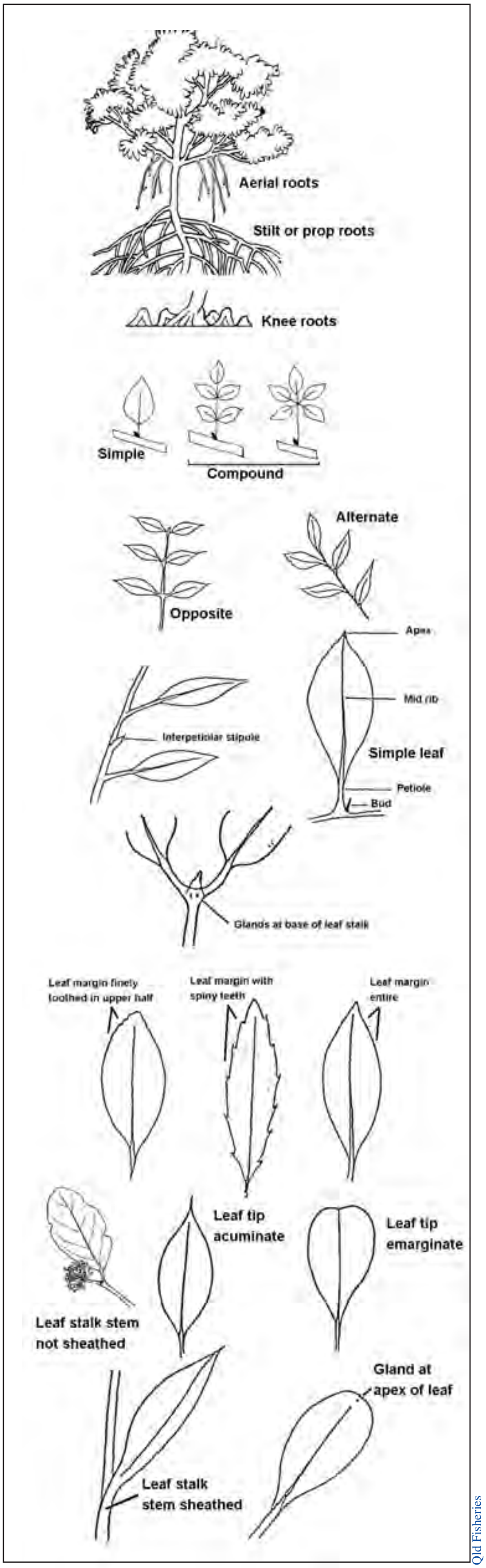
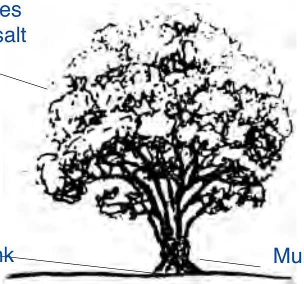


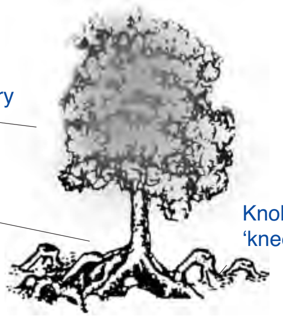
Figure 37.1 Information relevant to mangrove key

Whole tree

This key is based on easily observable characteristics such as roots, leaves and sap.



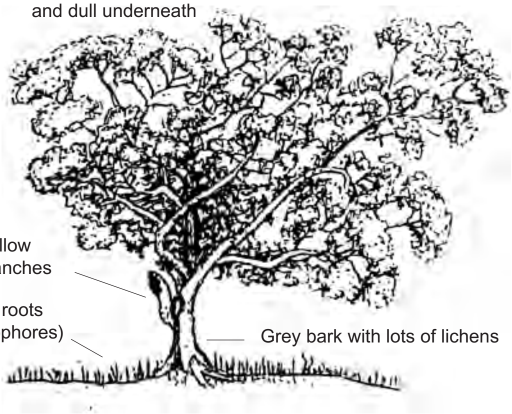
River mangrove



Orange mangrove

Yellow mangrove

Stilted mangrove



White or grey mangrove

Figure 38.1 Illustrations are from the Australian Littoral Society Moreton Bay Resource Kit and are reproduced with permission.

Fruit

This key is based on mangrove fruit of some species

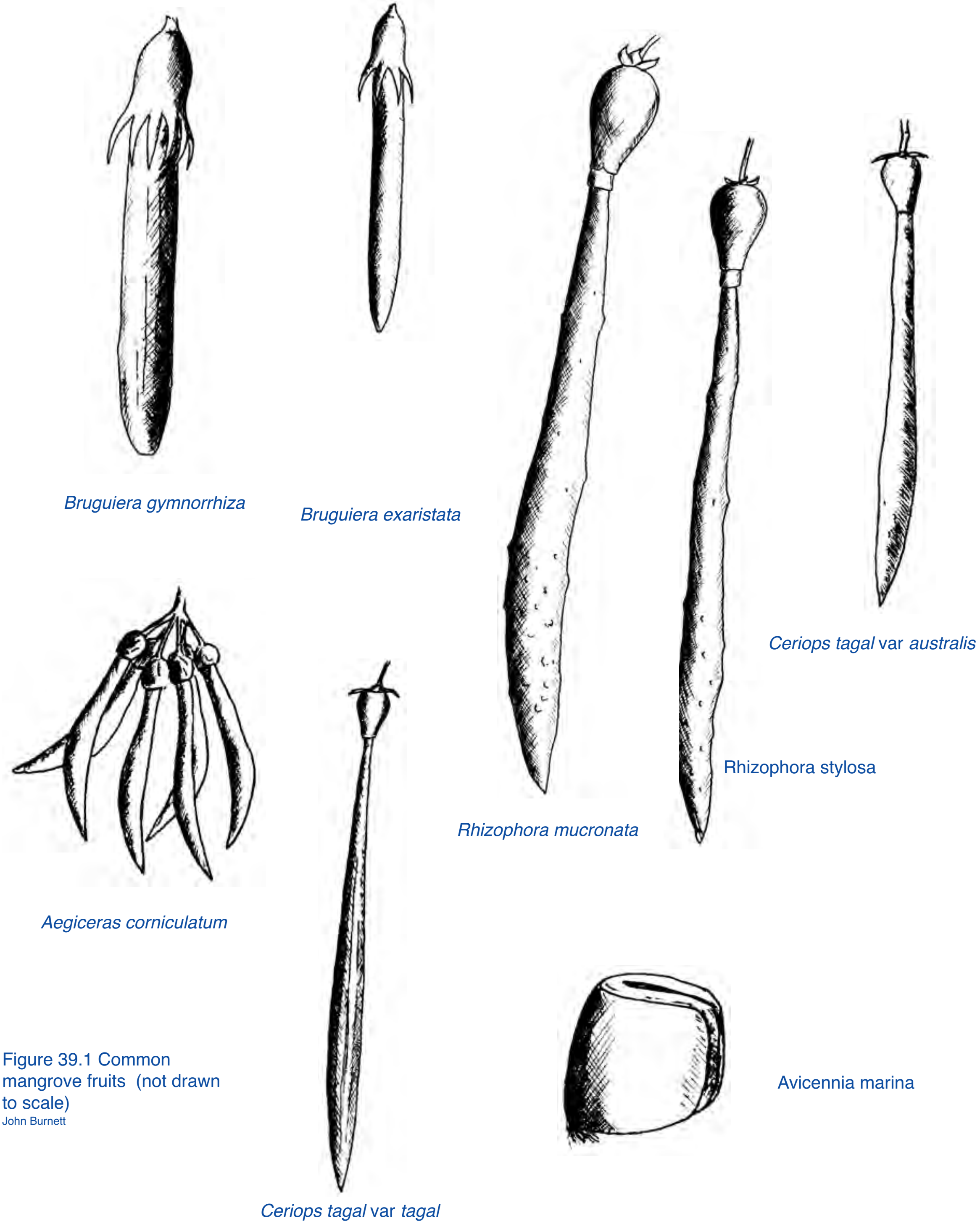
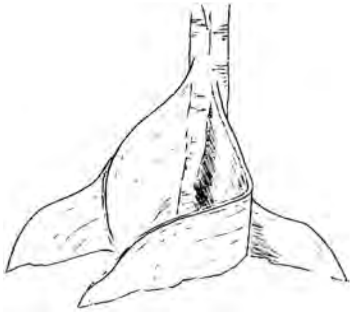


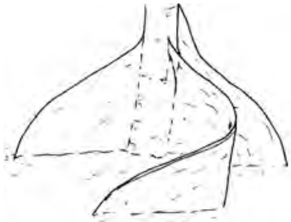
Figure 39.1 Common mangrove fruits (not drawn to scale)
John Burnett

Root systems

This key is based on matching the root system with the species name below.

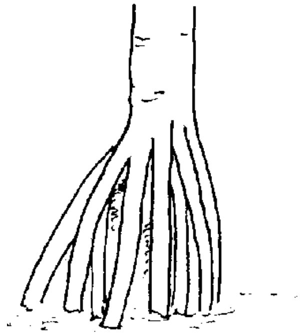


Heritiera littoralis

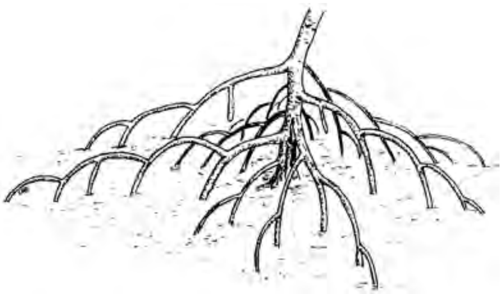


Heritiera littoralis

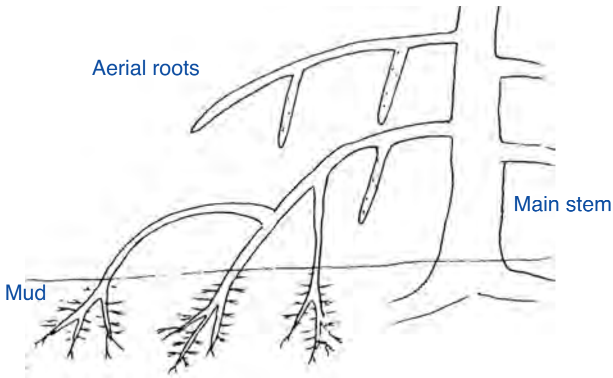
Bruguiera gymnorrhiza



Ceriops and *Bruguiera*



Rhizophora stylosa



Rhizophora stylosa

Figure 40.1 Common mangrove root systems (not drawn to scale) A crab order key based on local knowledge. After Jacobs Well Environmental Education Centre field key (Reproduced with permission).

Project 1.5 Crab study

After Jacobs Well EEC

What to do

Read the questions below and then use the crab identification key to identify a number of crabs. At the time of identification, note their habitat.

Research propositions

1. Describe the study area.
2. Estimate the salinity the crab's burrow.
3. Identify which plants crabs associate with. Are the numbers of the particular species predominant or simply scattered? Example: Is it salt marsh or yellow mangrove forest or open mud flat etc?
4. Verify if the area has a high level of tidal activity or if it an area where only the highest tides of the month reach.
5. Determine what type of soil is in the area (Use Figure 41.1 if applicable)
6. Describe what type of burrow the crab inhabits and where is it situated—is it in a bank, flat ground, mounded under mangroves or other?
7. Describe how different species of crabs behave when caught.
8. Determine the temperature of the mud and suggest a any relationship (if any) to the types of crab found.
9. Estimate percent exposure of crabs to sun.

Analyse your results

- Summarise your answers in a report or multimodal presentation.

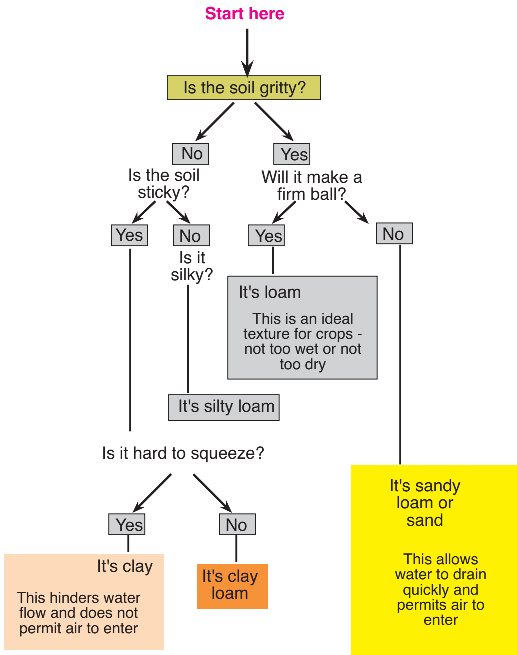


Figure 41.1 Soil key
Bob Moffatt

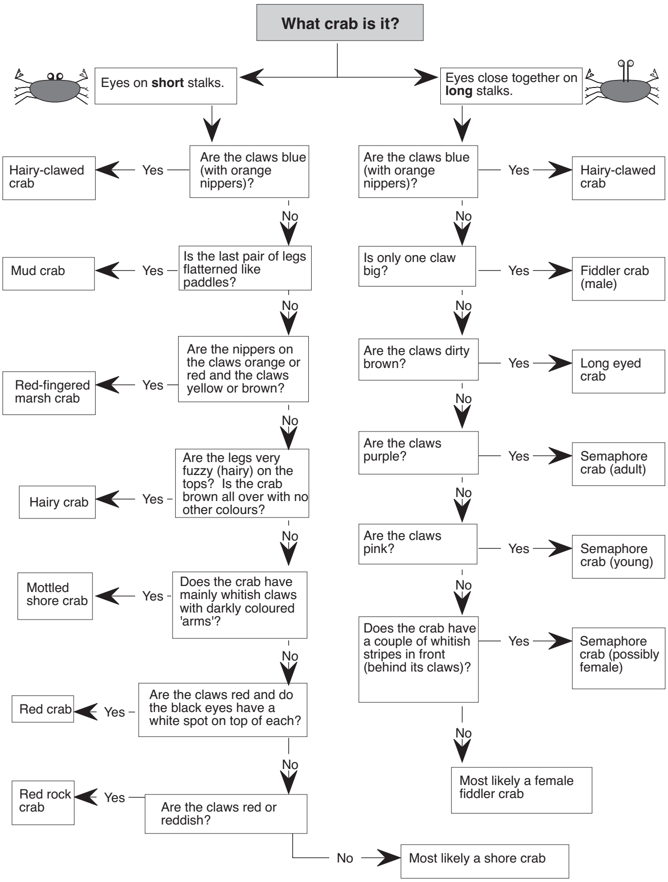


Figure 41.2 Crab key
Jacobs Well EEC

Project 1.6 Design a key

by Jacobs Well EEC

Design a non specific key for your local area mangroves like the one shown in Figure 42.1.

Analyse your results

Prove that your key works using other members of your class. Evaluate your success and present arguments for improvements.

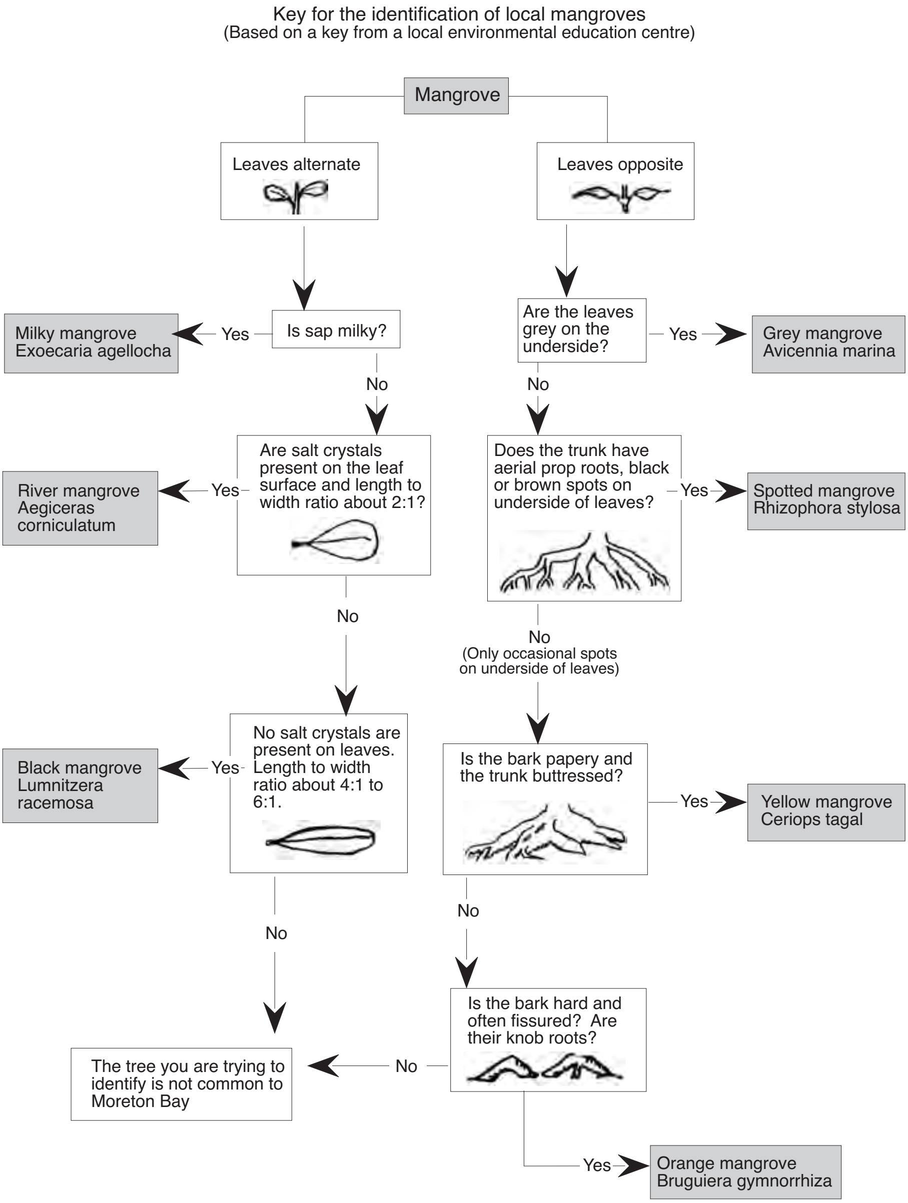


Figure 42.1 Jacobs Well Environmental Education Centre common mangrove root systems local key. (Reproduced with permission)

Chapter 2 Anatomy, physiology and adaptation

Anatomy and physiology

by Bob Moffatt

Plant anatomy is the study of the structure of organisms by studying cells, tissues and organs.

Plant physiology is the study of the function of these cells, tissues, organs as well as the physics and chemistry of these functions.

- In studying mangrove anatomy and physiology it is important to realise that structure always correlates to function.
- Just like animals, the study of mangrove anatomy and physiology can be organised from the simplest (eg atoms) to the most complex (eg communities). This can be summarised as:

  Atoms > molecules > cells > tissues > organs > whole plant > populations>communities.

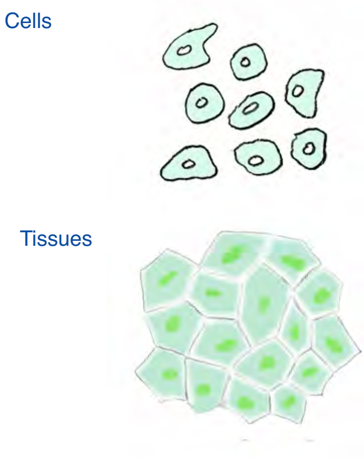


Figure 44.1 Cells and tissues
Bob Moffatt

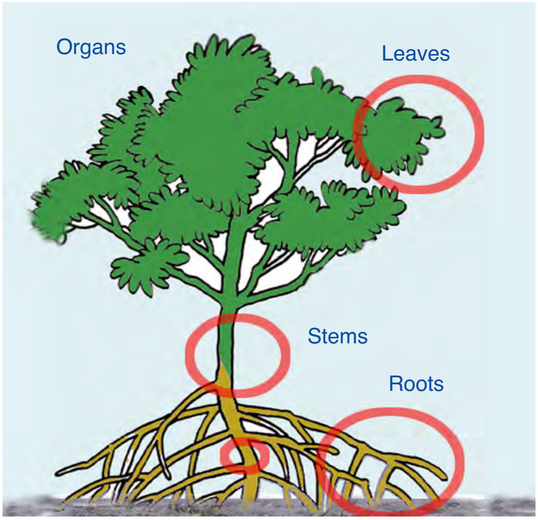


Figure 44.2 Organs and whole plant
Bob Moffatt

Atoms and molecules

Photosynthesis

Mangroves are different from animals in that they can make their own food using the sun.

The basic atoms involved in this process are

- oxygen, carbon and hydrogen which make up the molecules of:

  carbon dioxide

  oxygen

  water and

  sugar.
- The process is called photosynthesis, occurs primarily in leaves and is summarised in Figure 44.3 below.
- To make the process work, leaves contain a green pigment called chlorophyll and extract enzymes, water and nutrients from the roots and plant transport system.

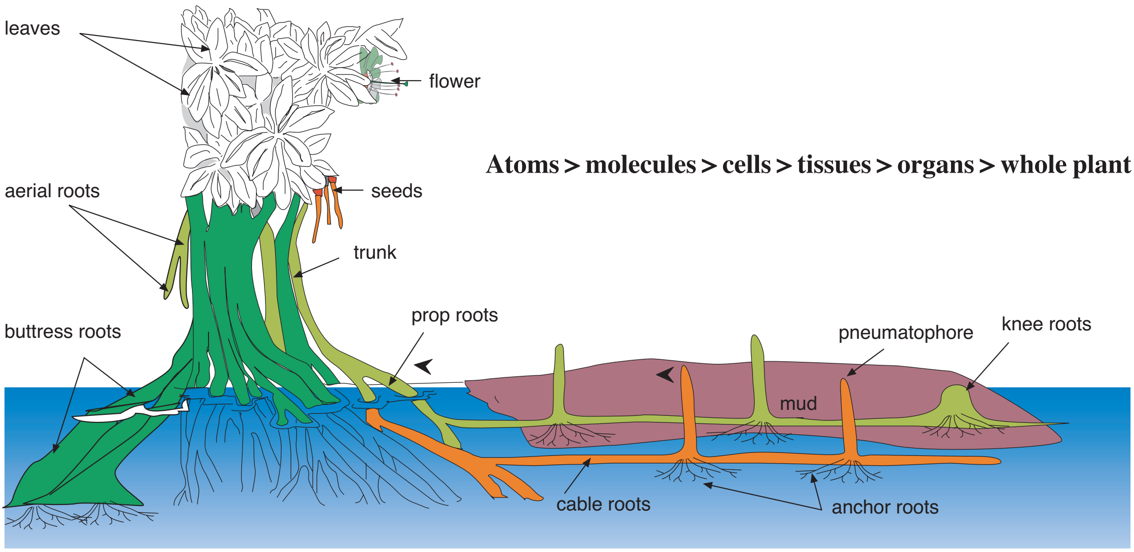
$$6\ C0_2 + 12\ H_20 \xrightarrow{\text{Light energy}} C_6H_{12}0_6 + 60_2 + 6\ H_20$$

six molecules of carbon dioxide | twelve molecules of water | Light energy: Chlorophyll enzymes and nutrients | one molecule of glucose (plant biomass) | six molecules of oxygen | six molecules of water

Figure 44.3 Photosynthesis requires sunlight
Bob Moffatt

Note

A further study of the atomic and molecular interactions of mangroves and how they affect the higher organisation of the plant is beyond the scope of this book.



Atoms > molecules > cells > tissues > organs > whole plant

Figure 45.1 Overall structure
Bob Moffatt

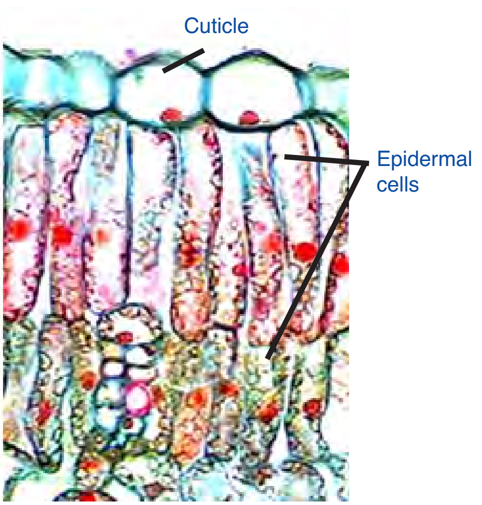


Figure 46.1 Epidermal cells
Bob Moffatt

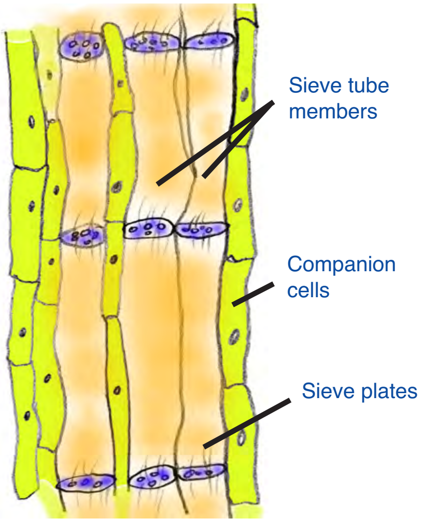


Figure 46.2 Phloem cells
Bob Moffatt

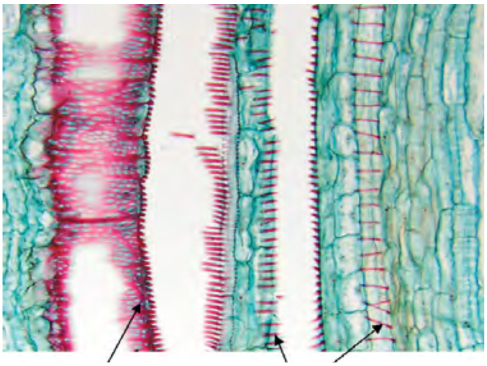


Figure 46.3 Xylem cells
Qld Fisheries

Plant cells

Plant cells are basic building blocks of mangroves. They specialize in their form and function by working together, forming tissues and support each other to ensure the individual mangrove survives.

Cells on the outside

The cells making up the outside of the mangrove are called epidermal cells. They are like the skin of the mangrove.

In stems and leaves, they have a cuticle or waxy layer that prevents water loss and in mangroves have specialised cells to desalinate the seawater (Figure 46.1).

Cells on the inside

Some of these cells transport water and organic materials (the sugars) throughout the plant and are made up of two main types – the xylem and phloem.

Phloem

Phloem cells transport organic materials (sugars).

- They are alive but lack a nucleus and organelle.
- Phloem composed of cells called sieve tube members.
- They have associated companion cells that join sieve tube members that help to load materials into sieve tube members.
- The end walls of sieve tube members have large pores called sieve plates.

Xylem

Xylem cells are dead, hollow and consist only of cell wall. They transport water and dissolved ions from the root to the stem and leaves.

Plant tissues (example leaf tissue)

Leaf tissue is composed of the upper and lower epidermis, vascular tissue called veins and filled in the middle with ground cells called the mesophyll, where most of this photosynthesis occurs.

Leaf epidermis

The upper epidermis is transparent so that sunlight can go through to the mesophyll layer. To prevent the leaf from drying out, the upper epidermis is covered with a waxy cuticle.

The lower epidermis contains small openings called stomata which open and close letting carbon dioxide and water in and oxygen out. Specialized cells called guard cells assist in this process.

Leaf epidermal cells are shown in Figure 47.1 on the next page.

Leaf mesophyll

The middle of the leaf is filled with photosynthetic cells called the mesophyll. Two types of cells reside here called parenchyma cells.

- Palisade parenchyma cells are long columns below epidermis and have lots chloroplasts for photosynthesis.
- Spongy parenchyma cells which are spherical with air spaces around them for gas exchange.

Leaf vascular tissue

Water and food transport in leaves occurs in vascular tissue called veins as shown in Figure 47.2. These are composed of a xylem (water transport) phloem (food transport) surrounded by cells called the bundle sheath giving the vein strength and support.

As the water molecules evaporate in the mesophyll layer and leave through the stoma, they pull adjacent water molecules out the leaf vein.

The end result is that continued evaporation from the leaf pulls a long chain of water molecules up the xylem from the roots, through the stem to the leaves. The plant can control the rate just by opening and closing its stomata.

You will get to observe these tissues if you complete the leaf sections lab exercise in this chapter.

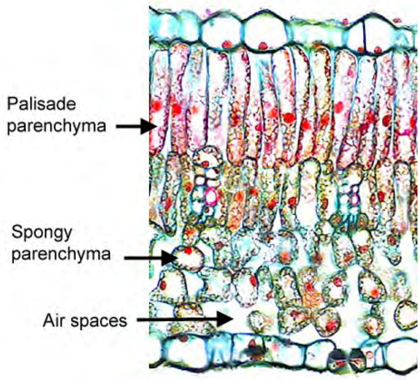


Figure 47.1 Leaf tissues
Qld Fisheries

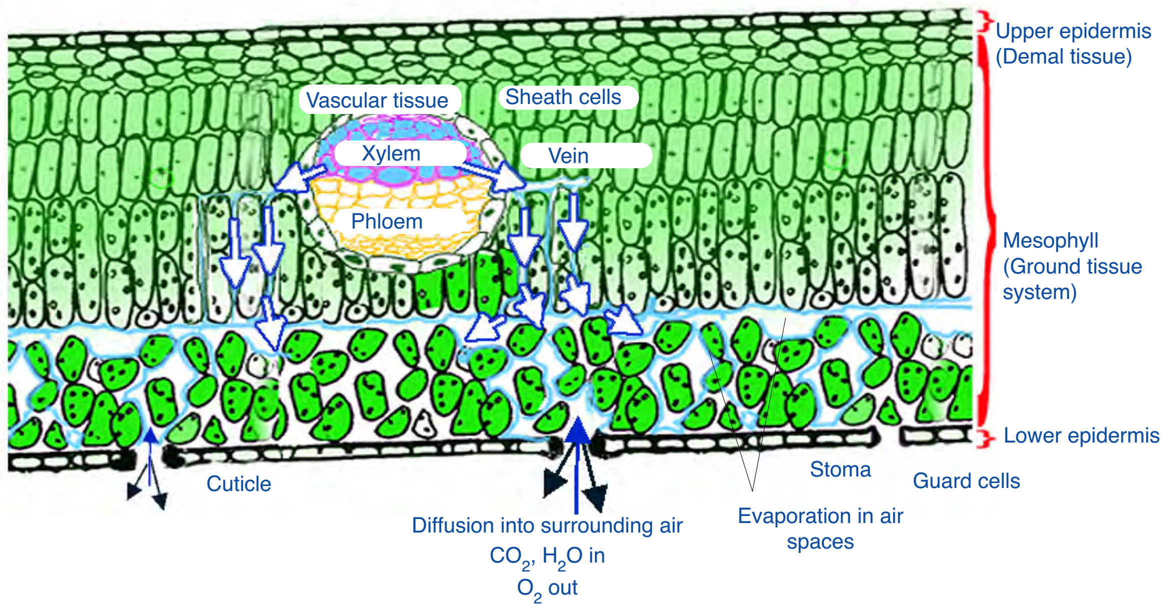


Figure 47.2 Water movement in leaf tissue
Bob Moffatt

From Wikipedia

Pressure flow hypothesis

"This was the pressure flow hypothesis, also known as the mass flow Hypothesis, is the best-supported theory to explain the movement of food through the phloem. It was proposed by Ernst Munch, a German plant physiologist in 1930.

A high concentration of organic substance inside cells of the phloem at a source, such as a leaf, creates a diffusion gradient (osmotic gradient) that draws water into the cells. Movement occurs by bulk flow (mass flow); phloem sap moves from sugar sources to sugar sinks by means of turgor pressure, also known as hydrostatic pressure.

A sugar source is any part of the plant that is producing or releasing sugar. During the plant's growth period, usually during the spring, storage organs such as the roots are sugar sources, and the plant's many growing areas are sugar sinks. The movement in phloem is bidirectional, whereas, in xylem cells, it is unidirectional (upward)."

Plant sugar translocation

Water and oxygen are not the only by products of photosynthesis as the plant needs food to grow.

This food is in the form of sugar and is created in the leaf mesophyll cells during photosynthesis. This sugar now diffuses to other parts of the plant by a process known as sugar translocation and occurs in the phloem.

Diffusion

Diffusion of sugar molecules in a plant is the movement of these molecules from a region of high concentration to a region of low concentration.

As there is a high concentration of sugar molecules in the mesophyll during photosyntheses and a low concentration in the phloem, sugar diffuses into the phloem.

Translocation

This is best summarised thus;

- Sugars made in leaf mesophyll cells diffuse into phloem cells located in the vascular bundles.
- Companion cells adjacent to the phloem cells then load these dissolved sugars into the phloem sieve tube members.
- Water from nearby xylem cells diffuses into the phloem creating pressure to force the sugar down the phloem.
- This is know as phloem sap.

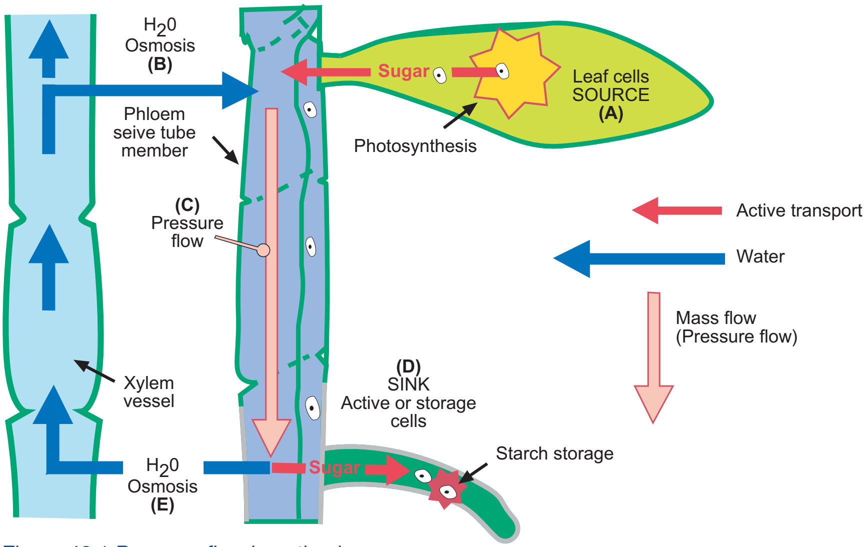


Figure 48.1 Pressure flow hypothesis
Bob Moffatt

Plant respiration

Plant respiration is a passive process that occurs in all plants for the purpose of releasing energy captured and stored within the plant.

It is the mechanism by which energy stored in the form of glucose is released for use in plant metabolism.

Glucose breakdown during plant respiration fuels the process of photosynthesis and plant growth

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + \text{ENERGY}$$

$C_6H_{12}O_6$	$6\ O_2$	$6\ CO_2$	$6\ H_2O$
one molecule of glucose (plant biomass)	six molecules of water	six molecules of carbon dioxide	six molecules of water

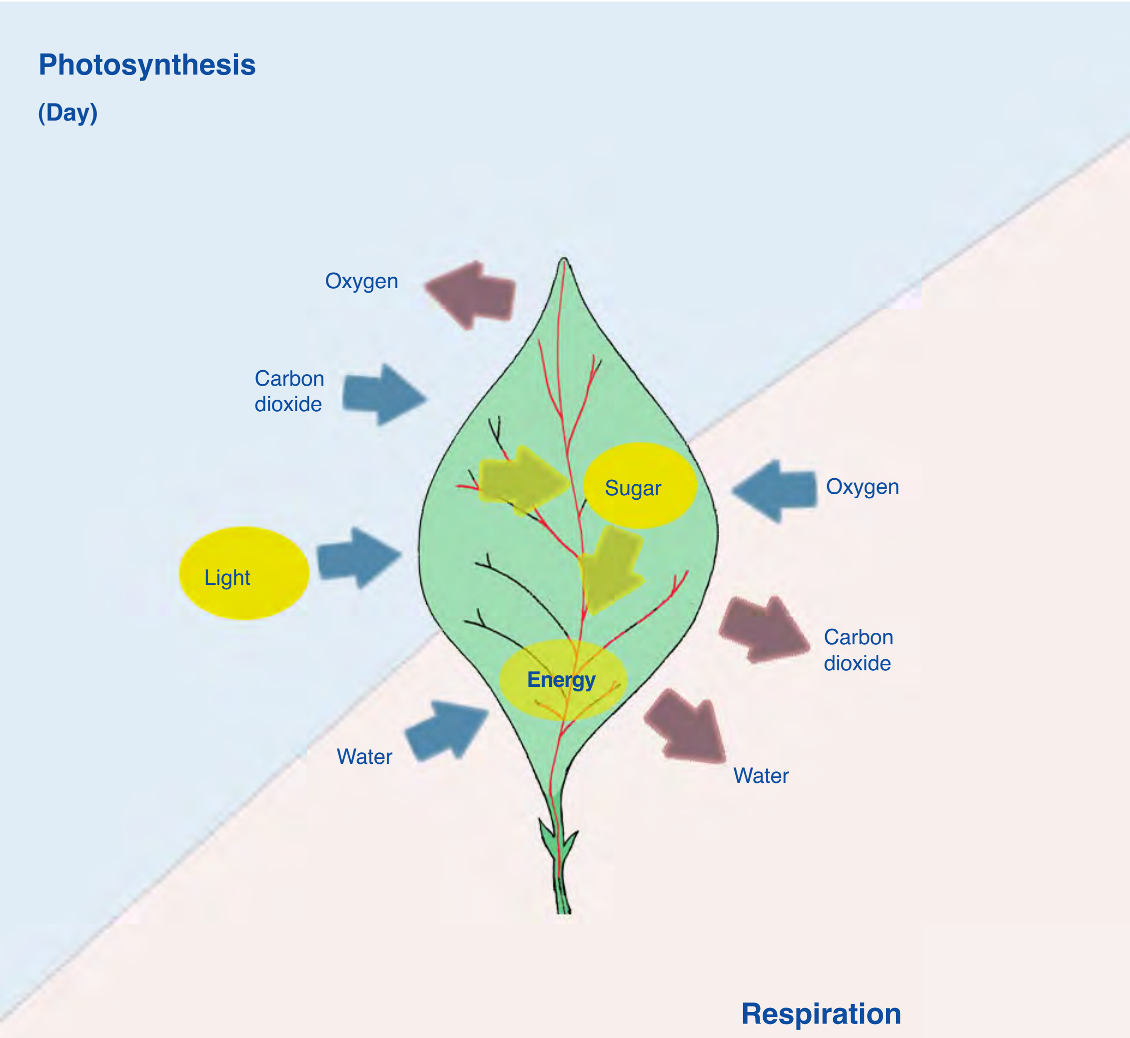


Figure 49.1 Leaf photosynthesis and respiration
Bob Moffatt

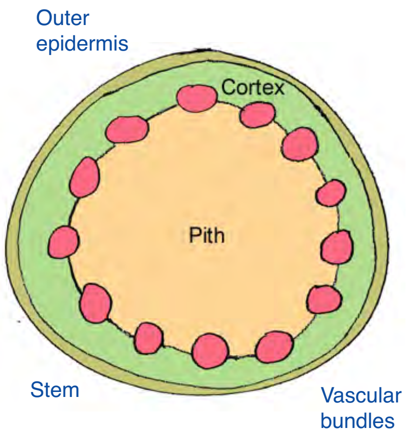


Figure 50.1 Vascular tissues in the stem
Bob Moffatt and Qld Fisheries

Stems

Stems support leaves and fruit as well as containing tissues to conduct water and sugars through the xylem and phloem.

Stem anatomy consists of an outer epidermis, with vascular bundles encircling the cortex.

The inner ground tissue stores food and forms a pith.

Mangroves have a woody stem with an epidermis providing protection to the plant's organs.

The stem vascular tissue forms vascular bundles – composed of both xylem and phloem.

- The xylem conducts water and provides support whereas the phloem conducts food as well as providing support.
  The vascular cambium occurs in woody stems
- Vascular cambium located in the middle of the vascular bundle, between xylem and phloem as shown in Figure 50.2.

Vascular tissue

Vascular tissue in mangroves is located on the outer layers of the tree and forms rings in trees.

Annual rings occur when the xylem formed by the vascular cambium during one growing season. One ring = one year

Plant organs (example roots)

Roots anchor the plant in the mud or sandy environment. They absorb water and dissolved minerals and store surplus sugars and starch made by the leaves.

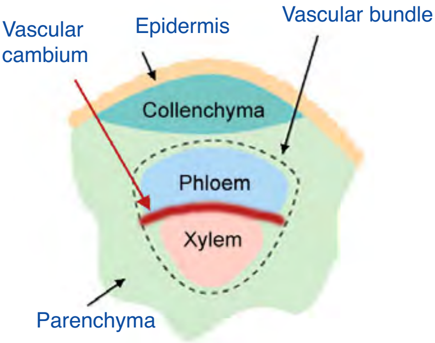


Figure 50.2 Vascular cambrium
Bob Moffatt

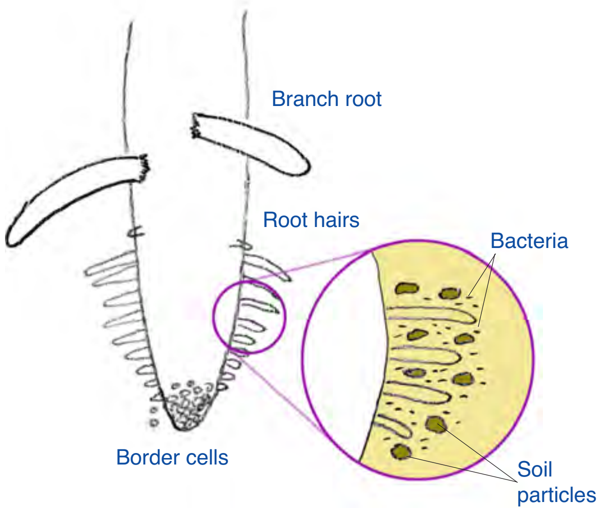


Figure 50.3 Root hairs
Bob Moffatt

Mangrove roots have an epidermis, which is an outermost layer of cells that protects the mangrove from disease and absorbs water when the tide comes in and nutrients from the mud.

In many mangroves, root hairs extend out from the epidermal cells, which increase the surface area of the root to increase water and nutrient absorption.

In roots, tissue, know as the cortex, provides support, and often stores sugars and starch.

The cortex is made of a innermost layer called the endodermis and is covered by a unique layer of cells called the casparian strip (Figure 51.2).

This is a water-impermeable strip of waxy material found in the endodermis.

The casparian strip helps to control the uptake of minerals into the xylem - they have to go through the cytoplasm of the cell.

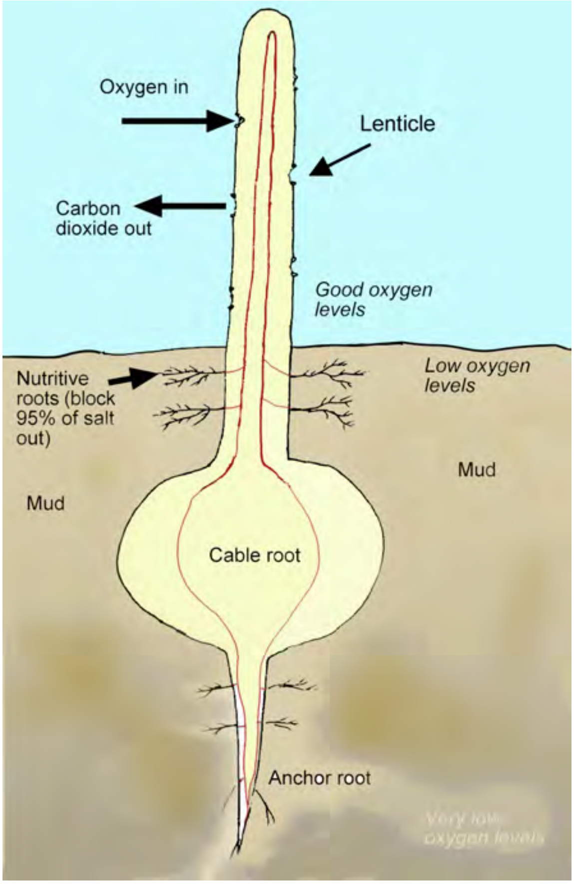


Figure 51.1 Longitudinal section of mangrove root
Bob Moffatt

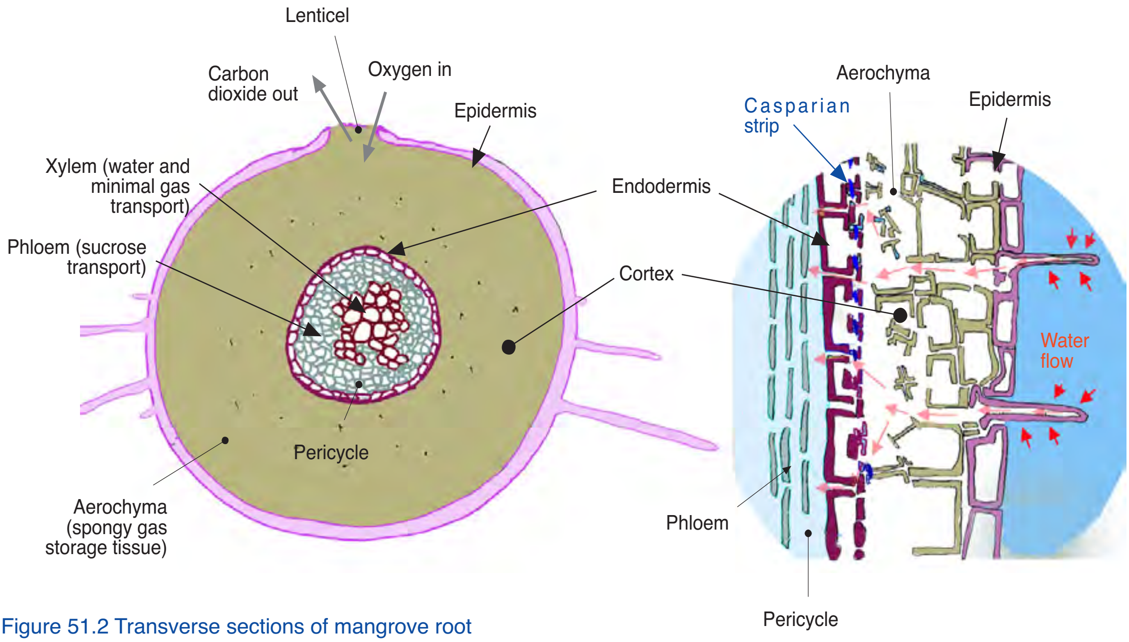


Figure 51.2 Transverse sections of mangrove root
Bob Moffatt

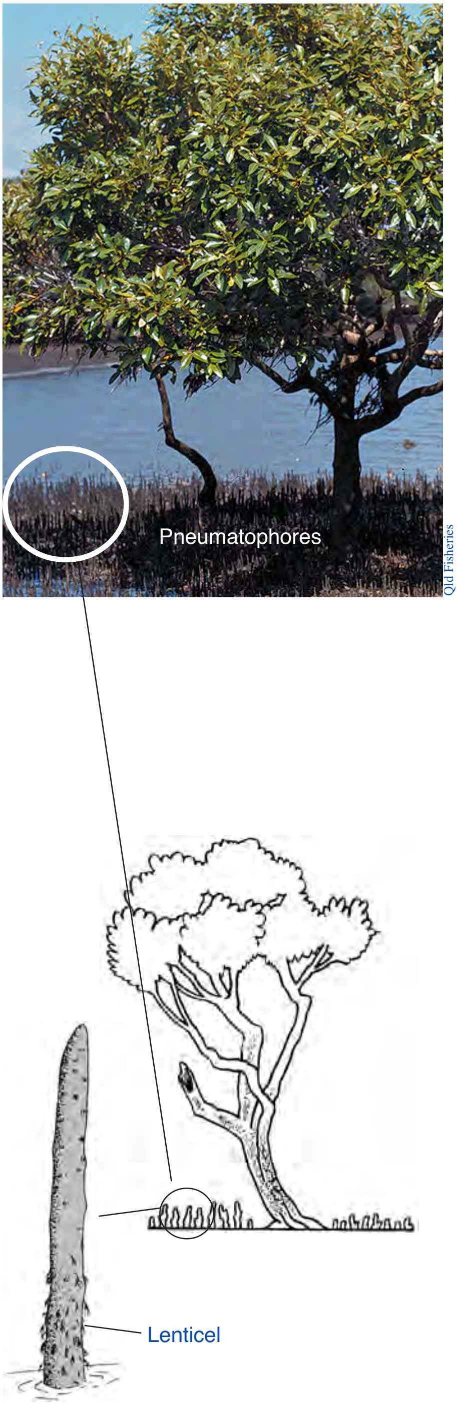


Fig 52.1 Pneumatophore and lenticel
John Burnett

Adaptations

by David Claridge

Mangroves are actually land plants that have developed a number of specialised adaptations that enable them to live in intertidal regions. The environment of the mangrove is very harsh: soils in which they grow are sometimes waterlogged, poorly aerated (i.e. deficient in oxygen), and high in salt.

These soils contain a great deal of decaying vegetable matter which creates noxious gases such as hydrogen sulphide and methane.

In pioneer areas at least, the substrate is regularly added to as a result of flood deposition. As well, mangroves have to survive regular tidal inundation, the effects of wave action, and the effect of dramatic temperature change.

Significance of adaptations

Humans can control the destiny of much marine life. An understanding of the adaptations of plants helps us develop ecologically sustainable economies. For example allowing storm water pipes to flow into wetland communities that can cope with sediment and nutrients is a better proposition than allowing them to flow into clean rocky shores or reefs.

If we understand the adaptations of marine organisms we can better plan for their survival.

Types of adaptations

Marine organisms continually battle for survival in the harsh world under the sea. Mangroves whether they live on land or in the water, depend on each other for nutrition and shelter.

They compete with each other for these necessities. Their surrounds or environment also affect the plant.. Organisms have had to adapt to all the different conditions that can be found in the sea; it is a case of adapt or die.

An adaptation is a characteristic that helps an organism survive. These types of adaptations include:

- structural (body form),
- functional (physiological), and
- behavioural.

Structural adaptations

Pneumatophores

Some mangroves grow pencil-like roots that stick up out of the dense, wet ground like snorkels. These breathing tubes, called pneumatophores, allow mangroves to cope with daily flooding by the tides.

During low tides, air is taken up through open passages in the pneumatophores and transported to living root tissues.

Fig 53.1 Pneumatophore system
Bob Moffatt

Roots

The roots support the tree while in the water, mud or loose sand, and contain transport systems and breathing pores for the exchange of gases.

In mangroves, respiration takes place by diffusion through lenticels in the roots and stems of plants.

To enable this to happen, mangroves have developed a number of specialised adaptations.

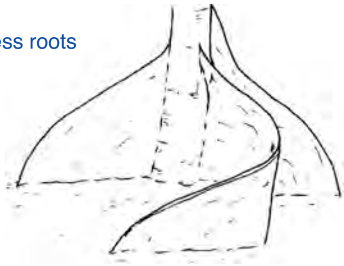
A walk through a mangrove forest will identify five different above ground root formations:

1. Pneumatophores are peg-like erect roots growing upwards from the cable root system and occur in *Avicennia, Sonneratia* and *Xylocarpus*
2. Stilt roots, which occur in *Rhizophora* and *Acanthus*, and are the distinctive curving prop roots which arch out from the trunk as shown in the figure below.
3. Buttress roots, which are found in *Ceriops*, *Heritiera* and *Xylocarpus*, are blade like structures at the base of the trunk.
4. Knee roots, which are loops in cable roots appear as knobbly knee like projections above the substrate as shown occur in *Bruguiera*, *Lumnitzera littorea*
5. Aerial roots, as shown in Figure 54.1, descend from the branches but do not enter the soil, and are found in *Avicennia* and *Rhizophora*.

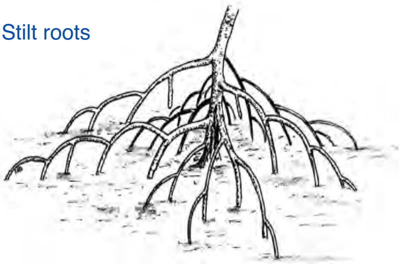
Saenger (see bibliography) cites evidence that these root structures are adaptations to root aeration, because the greatest variety of root variation occurs in species which occur on lower tide levels.

Whereas those species which are found on more aerobic, less waterlogged soils near the upper tidal limit do not possess specialised root systems e.g. *Excoecaria* and *Aegialitis*.

Buttress roots



Stilt roots



Knee roots

Aerial roots

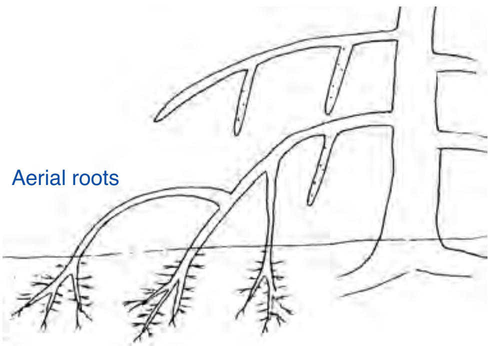


Figure 54.1 Root systems

Leaves

The tough epidermis of a mangrove helps it withstand wind, rain, salt and flood. The cuticle allows light in but prevents evaporation - so this is a structural adaptation (Figure 55.1).

Like desert plants, mangroves store fresh water in thick succulent leaves.

A waxy coating on the leaves of some mangrove species seals in water and minimizes evaporation. Small hairs on the leaves of other species deflect wind and sunlight, which reduces water loss through the tiny openings where gases enter and exit during photosynthesis. On some mangroves species, these tiny openings are below the leaf's surface, away from the drying wind and sun.

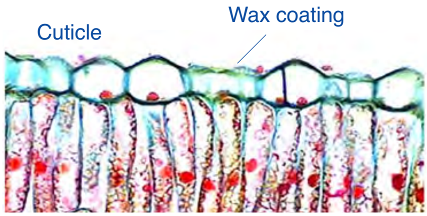


Figure 55.1 Leaf epidermis
Qld Fisheries

Functional (physiological) adaptations

Dealing with salt

Saltwater can kill plants, so mangroves must extract freshwater from the seawater that surrounds them. For example, many mangrove species survive by filtering out as much as 90 percent of the salt found in seawater as it enters their roots.

The mechanism by which salt content is regulated is a function of the whole plant and not individual parts. This involves one or a combination of the following processes—exclusion, excretion or accumulation.

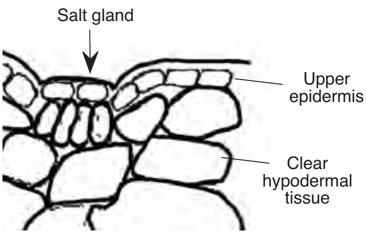


Figure 55.2 Salt secretion cells from upper epidermis of *Aegiceras corniculatum*
John Burnett

Exclusion

Plants, which are salt excluders have a sort of super filter, a selective absorption process which enables them to take in water and filter most of the salt out.

Salt glands

In mangroves the epidermis contains salt glands which are physiological adaptations that help photosynthesis by removing salt from the mesophyll layer. They are sunken in the upper epidermis and raised in the lower epidermis.

Some species excrete salt through glands in their leaves (Figure 55.2. These leaves, which are covered with dried salt crystals, taste salty if you lick them. A third strategy used by some mangrove species is to concentrate salt in older leaves or bark. When the leaves drop or the bark sheds, the stored salt goes with them.

Genera which are able to exclude salt include *Avicennia, Ceriops, Rhizophora, Bruguiera* and *Excoecaria*.

Qld Fisheries

Figure 55.3 Excretion

Excretion

Excretion occurs by means of salt glands in the leaves. Genera which are able to secrete salt often have a fine film of salt on their leaves, and include *Aegiceras, Aegialitis, Acanthus, Sonneratia* and *Avicennia*.

Many mangrove species employ a combination of methods to cope with the problem of salt. In this photo of *Aegiceras corniculatum* note the encrustation of salt on some of the leaves — the result of excretion.

In some regions, the most efficient of these is *Avicennia,* hence its ability to grow in highly saline conditions.

Aegiceras is less efficient and therefore is restricted to areas which are much less saline.

Accumulation

Mangroves which accumulate excess salt, deposit it in bark or old leaves. Species which do this often have succulent or thickened leaves and include *Osbornia, Excoecaria, Lumnitzera, Sonneratia* and *Xylocarpus*.

These leaves fall to the forest floor and become part of the detrital build up (Figure 56.1). For species such as *Xylocarpus* which are deciduous, scientists have theorised that the leaf fall each year is a prelude to the new growing season.

Dealing with substrate instability

All mangroves have a system of laterally spreading cable roots to which are attached the vertical anchor roots. From these go out the fine hair-like roots which extract nutrition from the soil. Mangrove root systems are invariably very shallow, and most species do not appear to have tap roots.

In mangrove areas, the amount of biomass under the ground is greater to that above ground thus reducing the chance of mangroves being washed away.

John Burnett

Figure 56.1 A stand of *Avicennia marina* in Spencer Gulf, South Australia, showing enormous amounts of leaf and sea grass litter. It is the bacteria and fungal breakdown of this litter which is the beginning of many marine food chains.

Reproduction

Flowers

Typically mangrove flowers have a stem on which grows petals and reproductive parts as shown in Figure 57.1.

Mangroves reproduce by male and female flower parts fertilising each other and forming a seed. In some species these seeds are specialised in that they germinate while still attached to the tree and are long and thin so that when they drop to the ground they stick in the mud. If they fail to strike, the seed is covered by a tough sheath to prevent it from drying out and enabling it to float.

Once the seed has anchored itself, roots quickly grow and a seedling forms. It may take many years for the seedling to grow to a young mangrove tree as shown in Figure 57.3.

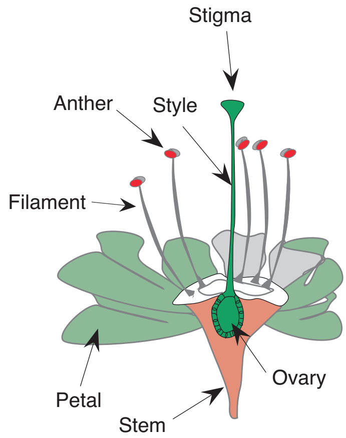


Figure 57.1 Generalised flower
Bob Moffatt

Bob Moffatt

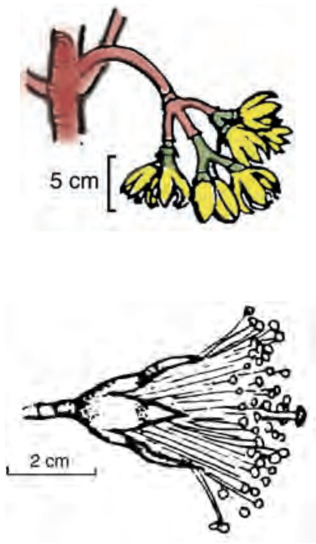


Figure 57.2 Mangrove flower
Michael Mitchie

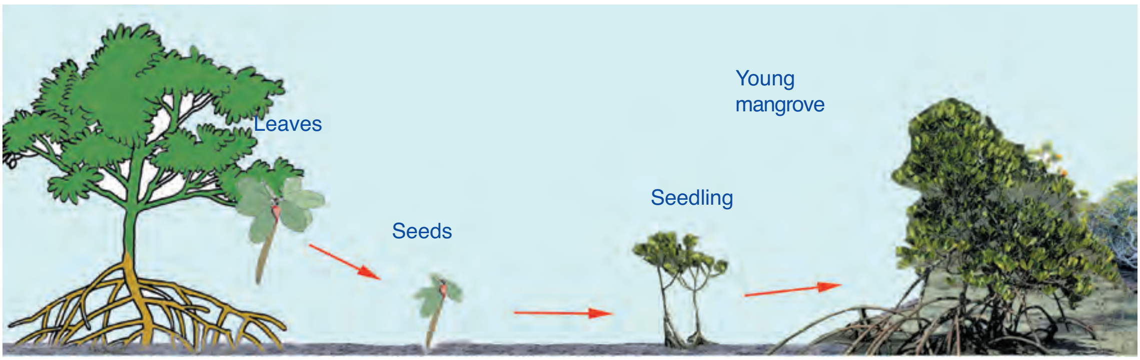


Figure 57.3 Mangrove life cycle
Bob Moffatt

Dealing with seed dispersal/ establishment

The mangroves' niche between land and sea has led to unique methods of reproduction.

Seed pods germinate while on the tree, so they are ready to take root when they drop. If a seed falls in the water during high tide, it can float and take root once it finds solid ground. If a sprout falls during low tide, it can quickly establish itself in the soft soil of tidal mudflats before the next tide comes in. A vigorous seed may grow up to two feet (about 0.6 m) in its first year. Roots arch from the seedling to anchor it in the mud. Some tree species form long, spear-shaped stems and roots while still attached to the parent plant. After being nourished by the parent tree for one to three years, these sprouts may break off. Some take root nearby while others fall into the water and are carried away to distant shores.

The seeds of mangroves are buoyant and are adapted to dispersal by water, sometimes over considerable distances. While the various mangrove species produce large crops of seeds each year, only a few successfully take root. The vast majority are washed up on beaches as debris mixed with the species of seeds from littoral forests and other flotsam. Many drift into populated areas where there is little chance of survival.

Mud banks exposed at low tide are formed of river silts in sheltered areas. Seedlings from the pioneer genera *Avicennia*, *Rhizophora* and *Sonneratia* soon find a foothold under these circumstances and the nucleus of a new forest is formed. When fully developed, the root network of these pioneer species firstly serves as a barrier to slow down tidal movement, secondly traps floating debris and silt during periods of inundation and thirdly maintains and builds up the level of the forest floor. This provides the conditions which allow other mangrove species to establish and form a forest.

The process of producing seedlings while attached to the parent plant (vivipary) is extremely rare outside the mangrove forest. Mangrove seeds/seedlings are dropped at an advanced stage when the root system is already partially developed. Vivipary is demonstrated in the following families — Rhizophoraceae (*Bruguiera, Ceriops, Rhizophora*), Verbenaceae (*Avicennia*) and Myrsinaceae (*Aegiceras*).

The cannonball mangrove (*Xylocarpus granatum*) produces a large round fruit about 100 mm in diameter which bursts on ripening and scatters its seeds, which float away on the tide.

Bob Moffatt

Figure 58.1 *Avicennia marina* shoot

Vivipary in mangroves maybe an adaptation to the marine environment (Macnae 1968); but it is not really clear how the species are served by the process, as there are a number of very successful non-viviparous mangroves, e.g. *Excoecaria, Osbornia, Xylocarpus* and *Lumnitzera*.

Behavioural

Mangroves live in very hostile environments, and the angle of the leaf is critical with such a limited fresh water supply and harsh temperature conditions. Horizontal leaves catch light but will heat up throughout the day. Vertical leaves stay cooler because they allow convection currents to flow past them, expose a smaller surface area to the sun, and some leaves can reflect heat off a reflective surface.

Example

Project 2.3 is an excellent example of a behavioural adaptation

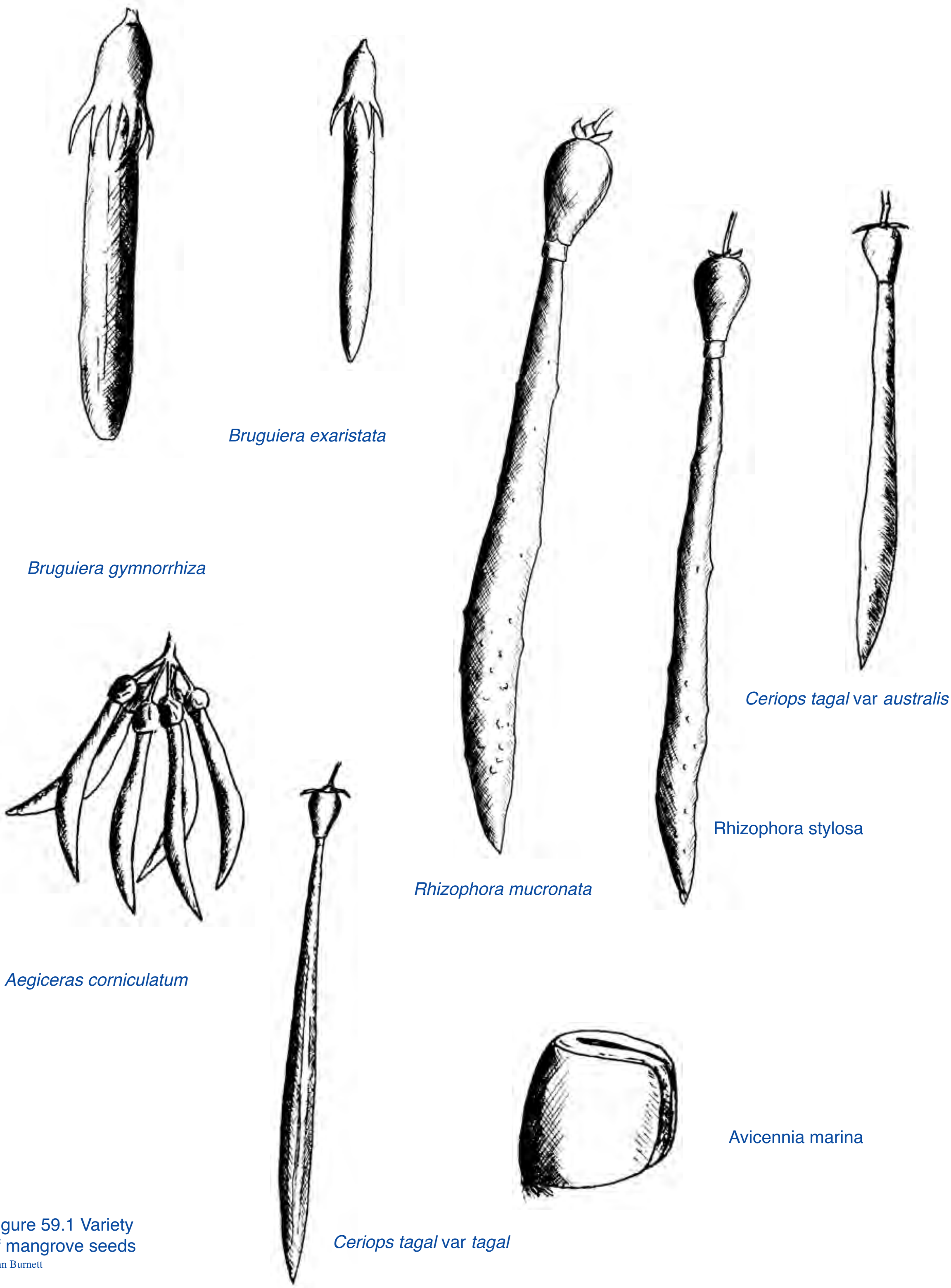


Figure 59.1 Variety of mangrove seeds
John Burnett

Lab exercise 2.1 Mangrove leaf sections

by John Burnett

The leaves of mangroves are unique in that their structural features vary from species to species, and may include salt secretion cells, hairs or scales on the epidermis, and a range of internal structures.

You will need

- mangrove leaf
- safety razor or scalpel
- petri dish
- microscope
- two microscope slides and coverslips
- copy of the reference books or laptop

What to do

1. Cut a square of leaf and place into a petri dish containing water. Carefully hold the leaf square underwater and make a number of thin cross sections as shown in Figure 60.1
2. Place some of the thinnest sections onto a slide, add a drop of water, and place on a coverslip.
3. Looking at the sections under the microscope, accurately draw what you observe, using a range of different mangroves. Use the drawings like the ones shown in Figure 59.4 on the next page to help.

Analyse your results

1. Identify the leaf you are dissecting.
2. Sketch (or draw) illustrations of the cross sections of mangrove leaves you use.
3. Estimate the size of the different types of cells.
4. Describe the methods used to make the transverse sections.
5. Explain how thin sections of mangrove leaves are prepared and describe how a microscope is used to identify cells.
6. Evaluate the methods used to make thin sections making suggestions for improvements.

Further research

1. Do distinct species of mangrove have distinct leaf structures?
2. Do salt secretion glands limit the distribution of mangrove species?
3. Can the epidermal thickness layer in mangrove leaves be related to adaptation?

John Burnett

Figure 60.1 Cutting mangrove sections in a petri dish

What you may observe

- *Avicennia marina*

  Upper epidermis: crater-like depression with sunken salt gland (Figure 61.1).

  Lower epidermis - raised salt glands, bulbous hairs and stomates (Figure 61.2).
- *Aegiceras corniculatum*

  Salt secreting cells (Figure 61.3).

Other observations you may notice

- *Rhizophora stylosa* - differentiation of hypodermis
- *Heritiera littoralis*- scales on lower epidermis
- *Hibiscus tiliaceus* - hairs on lower epidermis
- *Acrostichum speciosum* - accessory transfusion tissue in the central region of the leaf
- *Acanthus ilicifolius* - lower cuticle absent
- *Bruguiera gymnorrhiza* - several layers of lower hypodermis
- *Excoecaria agallocha*, *Xylocarpus mekongensis* - elongated upper hypodermis
- *Aegialitis annulata* - both spongy mesophyll and hypodermis absent.
- *Ceriops tagal* - has upper and lower hypodermis and enlarged mesophyll cells
- *Sonneratia caseolaris*, *Lumnitzera racemosa* - enlarged water storage cells in mesophyll layer

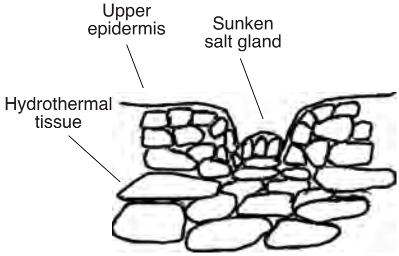


Figure 61.1 Upper epidermis *Avicennia marina* leaf
John Burnett

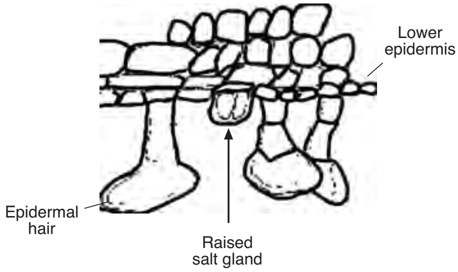


Figure 61.2 Lower epidermis *Avicennia marina* leaf
John Burnett

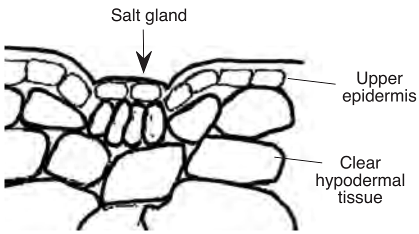


Figure 61.3 Salt secretion cells from upper epidermis of *Aegiceras corniculatum*
John Burnett

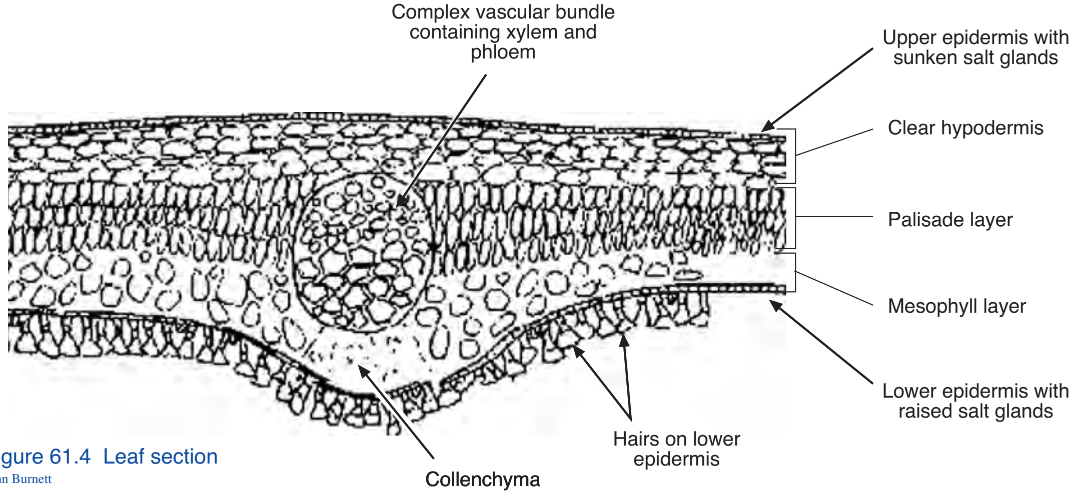


Figure 61.4 Leaf section
John Burnett

Lab exercise 2.2 Mangrove leaf epidermis

You will need

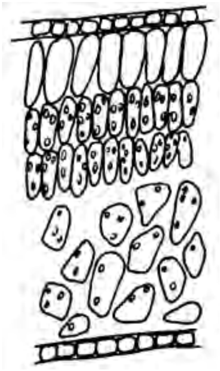
- variety of mangrove leaves
- safety razor or scalpel
- petri dish
- microscope
- two microscope slides and coverslips
- copy of the reference books or laptop

What to do

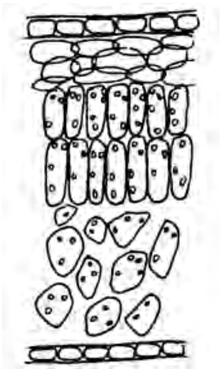
1. Roll the leaf (try doing this to *Avicennia marina* first) around your finger and use a safety razor or a scalpel to carefully shave off sections of the upper epidermis.
2. Place on a clean slide, add a drop of water and add a cover slip.
3. Observe using a microscope under low magnification and find a salt secreting gland on the epidermis. Now observe under high power.
4. Repeat the process but on the lower epidermis.
   You may need to shave the hairs off *Avicennia* first before removing the epidermis.
5. Now observe the epidermis of some of the other mangrove leaves.

Analyse your results

1. Identify the species you are dissecting
2. Sketch (or draw) illustrations of the cross sections of mangrove leaves you use. A number of possible observations of different mangrove species are shown in the Figures on this page.
3. Estimate the size of the different types of cells.
4. Compare cellular organisation between the difference species

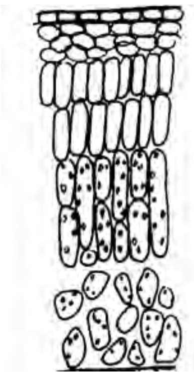


Excoecaria



Aegiceras

Fig 62.1 Transverse sections of *Excoecaria and Aegiceras*
John Burnett



Rhizophora

Ceriops

Fig 62.2 Transverse sections of *Rhizophora and Ceriops* leave's with their distinctive features
John Burnett

Lab exercise 2.3 Salt secretion

by John Burnett

Aim

The role of the salt secretion cells of a mangrove leaf is to excrete excess salt and water onto the surface of the leaf. This exercise will determine which plants excrete and from which part of the leaf these cells are located and how efficient they are in excreting salt.

You will need

- leaves of a number of mangrove species
- scalpel or safety razor
- petri dishes
- different salt solutions - fresh to hypersaline (see Figure 63.2).

What to do

1. From each type of mangrove leaf cut squares of 40 mm^2.
2. Place the range of salt solutions into the petri dishes.
3. In each petri dish place two squares: one shiny side up and the other shiny side down.
4. Observe the dishes after one to two days.

Analyse your results

1. Identify which mangroves are salt excretors.
2. Describe which is the most efficient mangrove excretor and which is the least efficient excretor. Contrast these differences.
3. Determine which side of the leaf is the most effective at salt excretion (i.e. which side has the highest concentration of salt secreting cells).

Figure 63.1 Avicennia marina leaves
John Burnett

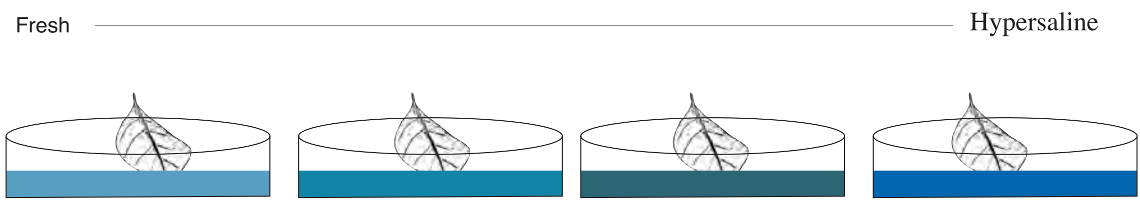


Figure 63.2 Range of salt solutions and leafs
Bob Moffatt

Lab exercise 2.4
Pneumatophore morphology

by John Burnett

Pneumatophores are structures that stick out of the mud and substrate, growing out of the lateral cable roots that radiate out from the tree trunk. The mangrove most often associated with these peg-like pneumatophores is the grey mangrove (*Avicennia marina*).

*Morphology**

In biology, morphology is a branch of bioscience dealing with the study of the form and structure of organisms and their specific structural features.

This includes aspects of the outward appearance (shape, structure, colour, pattern) as well as the form and structure of the internal parts like bones and organs.

You will need

- pneumatophore from *Avicennia marina*
- microscope safety razor or scalpel
- two microscope slides and cover slips
- stain (iodine or methylene blue)
- plastic bag
- rubber band

What to do

1. Carefully examine and squeeze the pneumatophore, sketch the main structure.
2. Examine the outside of the pneumatophore. Note the numerous corky spots on the surface.
3. To find the function of these structures, which is associated with gas exchange, you will need to do a simple exercise.
    a. Firstly cut the corner of a plastic bag and slip the open corner over the cut end of a pneumatophore, securing and sealing it with a rubber band
    b. Blow up the bag using the main opening and twist off the end. Place the end of the pneumatophore in a beaker of water, and gently squeeze the plastic bag. Watch the lenticels and make notes.
4. To observe how the pneumatophore functions you need to examine it microscopically.
    a. Using a new safety razor (or a scalpel) cut a number of thin LS and TS sections of the pneumatophore (see illustrations on the page opposite)
    b. Carefully make a wet slide of a section and stain it using methylene blue

    Examine under low power of a microscope and make notes.

Analyse your results

1. Sketch the lenticles and describe how they feel. Justify your answer with a comparison.
2. Describe what happens in the plastic bag experiment
3. Sketch (or draw) illustrations of the cross sections of what you observe.
4. Explain the term morphology using pneumatophores as an example.

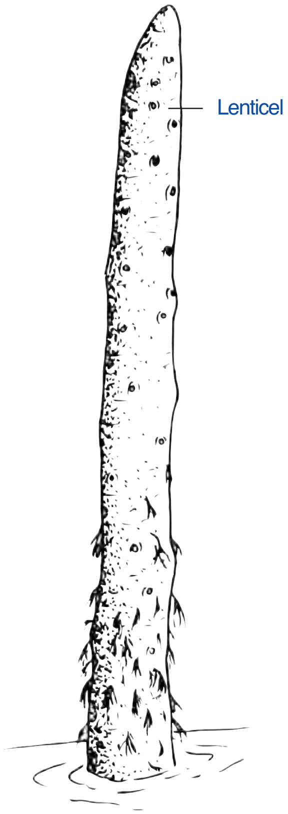


Fig 65.1 Pneumatophore and lenticel
John Burnett

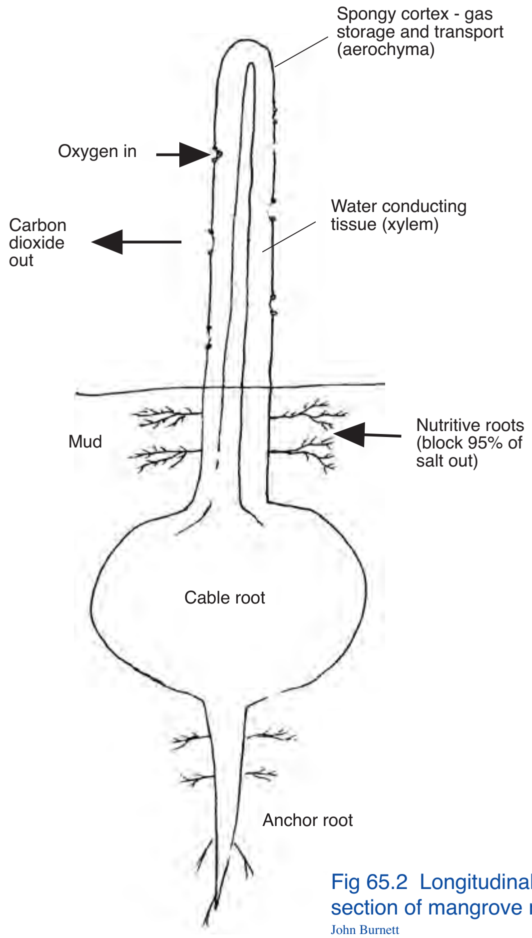


Fig 65.2 Longitudinal section of mangrove root
John Burnett

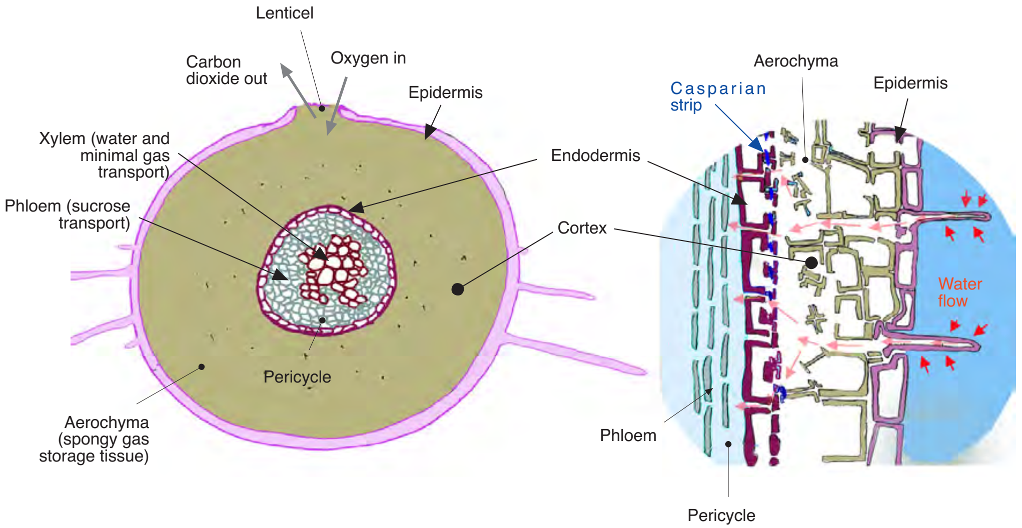


Fig 65.3 Transverse section of mangrove root
Bob Moffatt

Teacher's demonstration and class discussion

by John Burnett

Since the previous experiment demonstrated that gas can move out of a pneumatophore, this demonstration shows how gas can move into and through a pneumatophore through the lenticel and the aerenchyma.

You will need

- large syringe
- short lengths of plastic tube
- large test tube
- cork to fit the test tube with large hole in the middle
- concentrated nitric acid (see note)
- copper pieces
- petroleum jelly
- 'new' pneumatophore from *Avicennia* sp

What to do

1. Make up the apparatus as shown in Figure 66.1.
2. Use petroleum jelly to seal all joins to the syringe, including around the pneumatophore.
3. Place the copper into the acid and seal test tube with the cork.

   When the tube is filled with the brown gas, nitrogen dioxide (CARE POISONOUS GAS), carefully pull out the plunger of the syringe.

   The brownish gas will now be visible in the syringe.

Analyse your results

1. The different phyla of Kingdom Plantae and contain distinct anatomical and physiological structures, which are observed through dissection and experimentation.

   Explain how this demonstration explains this statement?
2. Describe the safety precautions and risks involved in this experiment.

   Justify the use a fume cupboard.
3. Identify the chemical compounds used in this experiment and explain the colours in terms of chemical reactions.

   Summarise your findings in a table.

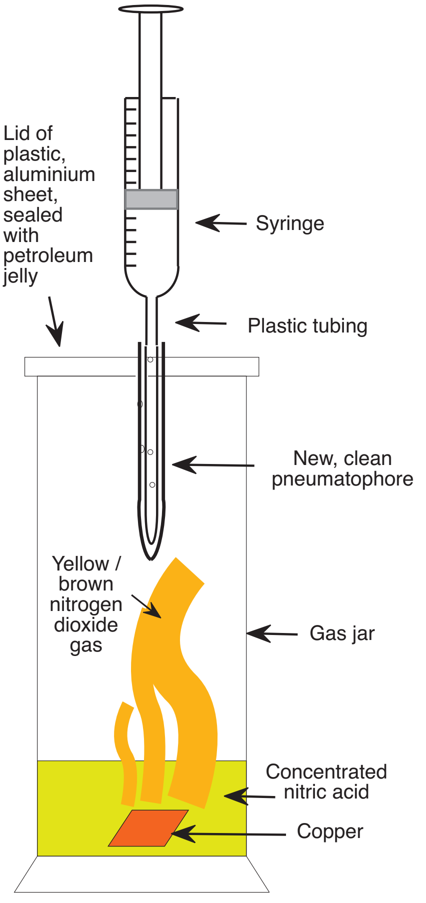


Figure 66.1 Note this demonstration should be done in a fume cupboard.
Bob Moffatt

Lab exercise 2.5 Salt levels in leaves

by John Burnett

Aim

To compare the salt concentrations in the leaves of a range of mangrove and wetland species.

You will need

- deionised water
- mortar and pestle
- 10 mL measuring cylinder
- salt meter vial or small beaker
- range of mangrove leaves (some old and yellow).

What to do

1. Crush the leaves of the plant that you wish to test in a mortar and pestle.
2. Place 2 g of ground leaves into a small beaker and then add 18 mL of deionised water and mix well.
3. Test the solution using a salt meter (if no salt meter is available use the mini titration method).

Problems

1. Indicate which mangrove species leaves you are using.
2. Compare the salinity of the leaves of a number of different species of mangrove.
2. Compare the salinity of leaves of salt excluders, such as *Rhizophora*, *Sonneratia*, *Lumnitzera* and *Bruguiera*, in particular compare new leaves with old discoloured (yellow) leaves.
3. Describe and evaluate your laboratory procedures.

Halophytes

A halophyte is a plant that can tolerate saline conditions. The majority of mangroves and the associated plants of the wetlands and saltpans, eg. samphires, have a tolerance to high external salt concentrations because they possess a high internal concentration of salt in their sap.

Other mangroves, such as *Rhizophora* and *Sonneratia* remove salt and store it in older leaves, which they later shed.

Figure 67.1 Mortar and pestle
Source unknown

Figure 67.2 Variety of mangrove leaves
Bob Moffatt

Project 2.1 Seedlings and salinity

by John Burnett

Aim

To determine the influence of salt water on a growing mangrove seedling.

What to do

1. Select a number of similar size seedlings growing in pots (see previous experiment). They must all be subject to the same variable (sun light, temperature, type of soil mix, etc). The only changing variable is the salt concentration from distilled water to hypersaline (saltier than sea water). Try using the following concentrations; distilled water and 50% and 100% sea water.
2. Top up the pots as they dry using only distilled water.
3. Examine each plant daily and record all observations.

Analyse your results

1. Compare how various salt concentrations affect mangrove growth.
2. Identify which concentrations are the most detrimental to the seedlings. Explain your answer.
3. Compare the variation in salinity levels in the water with the amount of salt crystal appearing on the leaves. (You could even measure the salt on the leaves).
4. Explain how the seedlings are able to survive the various saline conditions.

Figure 68.1 *Avicennia* seeds
Bob Moffatt

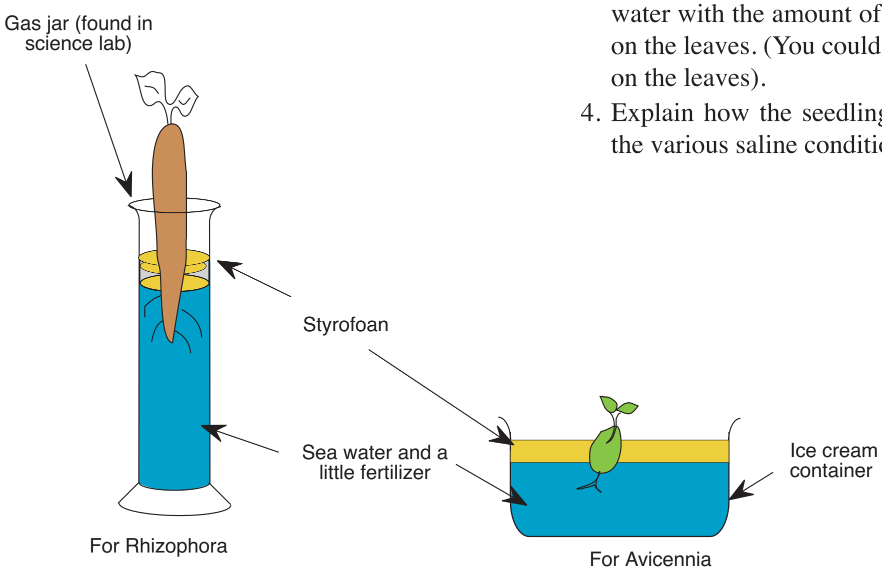


Figure 68.2 Hydroponic techniques for *Avicennia* sp
Bob Moffatt

Project 2.2 Fruit germinating and salinity

by John Burnett

The fruit of *Avicennia* is surrounded by a buoyant outer covering. This allows the fruit to float away from the parent tree and increases the rate of dispersal of the species.

This is important because *Avicennia* is a colonising plant and needs to spread to newly exposed mud banks. The fruit continues to float until the covering splits, releasing the developing young plant which is then washed ashore.

You will need

- *Avicennia* fruit with outer covering
- beakers
- various salt solutions (distilled water, 5 g/L, 10 g/L, 15 g/L, 20 g/L, 25 g/L, 30 g/L, 35 g/L, 40 g/L, sea water)

What to do

1. Place one *Avicennia* fruit into each beaker. Leave for two or three days.
2. Record the time that any outer covering splits and the new plant is released.
3. Calculate the time from entering the water until splitting.

Analyse your results

1. Draw a graph to show the relationship between salinity levels and percent germination.
   Explain your results.
2. Describe where would you expect to find areas with high and low salinity levels in mangrove environments. Explain your answer.
3. Explain why is it beneficial for mangrove species to be released into pure seawater.
4. Suggest why dilute salt solutions are essential for survival of mangrove seedlings.

Figure 69.1 Experimental design
Bob Moffatt

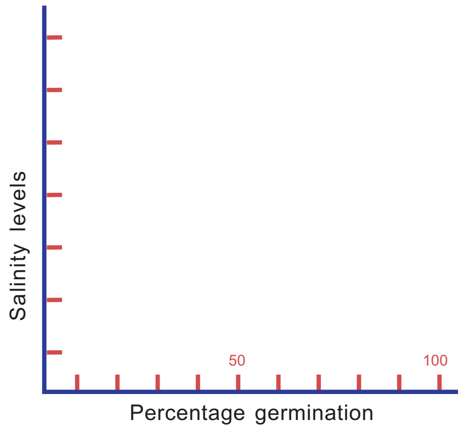


Figure 69.2 Sample graph
Bob Moffatt

Project 2.3 Leaf angles

by John Burnett

Mangroves live in very hostile environments, and the angle of the leaf is critical with such a limited fresh water supply and harsh temperature conditions. Horizontal leaves catch light but will heat up throughout the day. Vertical leaves stay cooler because they allow convection currents to flow past them, expose a smaller surface area to the sun, and some leaves can reflect heat off a reflective surface.

What to do

1. Build the clinometer as shown in Figure 70.1.
2. To take a reading make sure the clinometer is level. Place the clinometer near the leaf to be measured and lay the pointer across the leaf blade.
3. Read the angle off the protractor and record in your note book.
4. Repeat the measurements every 30 minutes on the same leaf.
5. Identify which species of mangrove tilt their leaves.

Analyse your results

1. Evaluate your experimental methods.
2. Compare leaf angles from the top to the lower part of the tree.
3. Describe the effect that the time of the day and the position of the sun have on the angle of the leaves. Draw a graph of your results showing the relationships between time of day and leaf angle.
4. Compare leaf angles between landward and seaward plants.
5. Propose a hypothesis involving the age of the plant and the leaf angle.

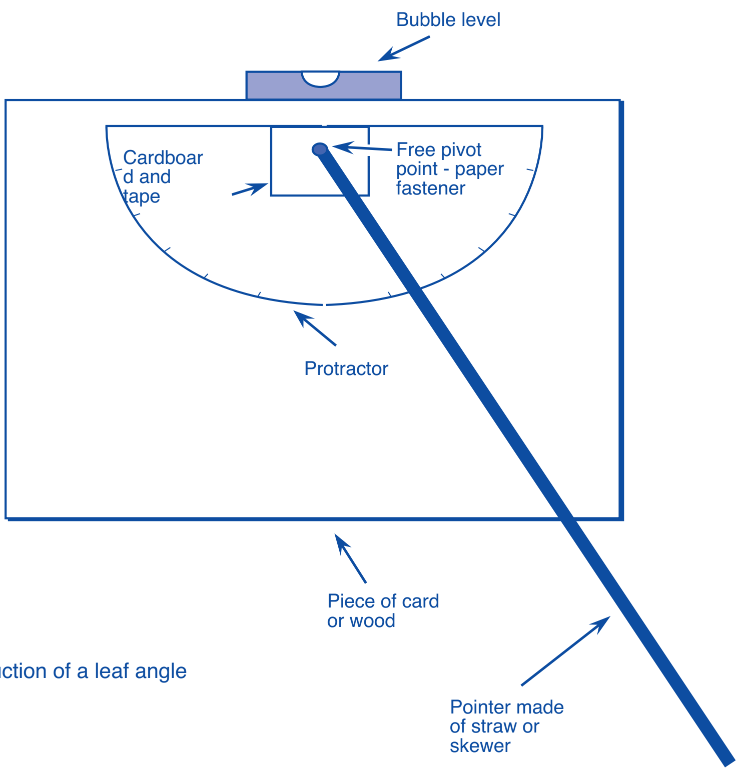


Figure 70.1 Construction of a leaf angle clinometer
Bob Moffatt

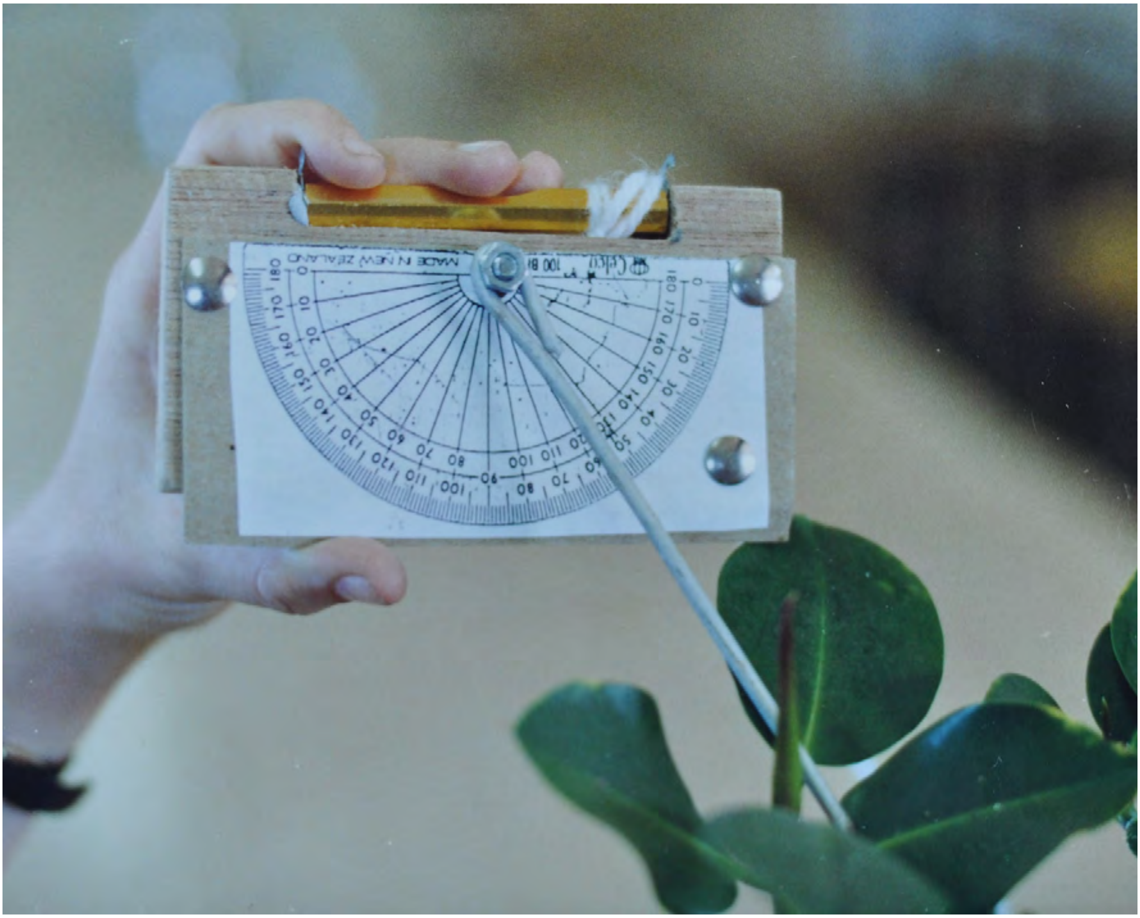


Figure 71.1 Using the home-made clinometer
John Burnett

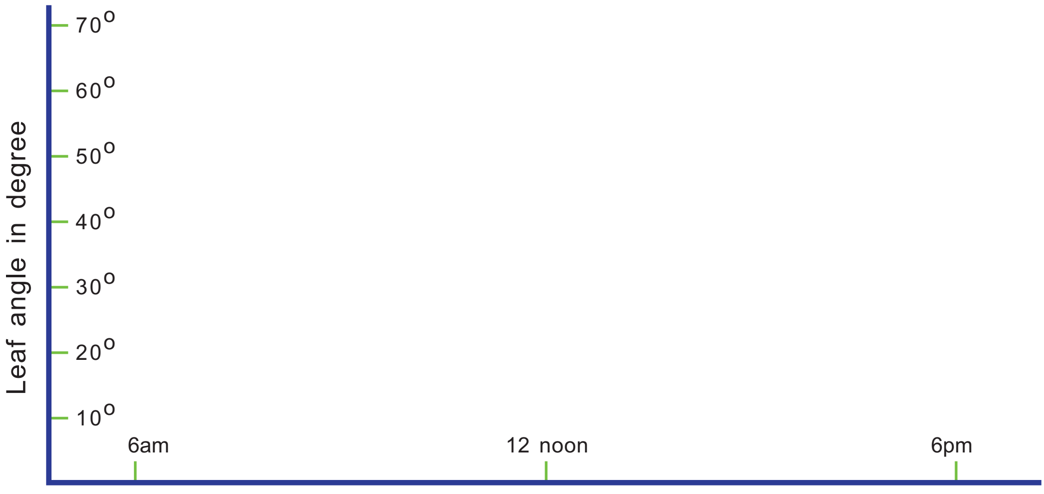


Figure 71.2 Sample graph
Bob Moffatt

Project 2.4 Width and length ratios

by John Burnett

Studies in Malaysia have demonstrated that there is a variation in the leaf width/length ratio between natural unaltered mangroves and disturbed mangrove forests, such as near a cleared area.

Method

1. Find a species of mangrove in the undisturbed section of a mangrove forest, and measure the width and length of at least ten leaf blades from those trees as shown in Figure 72.1.
2. Calculate width/length and record. Repeat on at least five other trees of the same species.
3. Repeat the measurements but on trees of the same species in disturbed area.
4. Plot the data onto a graph as shown in Figure 72.2, using different colours for disturbed and undisturbed areas.
5. Repeat this exercise but use another species of mangrove from an undisturbed area and disturbed area.

Analyse your results

1. Design a hypothesis to compare and contrast the width of the blade with its length from the two different areas.
2. Describe any differences that exists within each species.
3. Describe any variations in the ratios between the leaves from trees in the undisturbed area to trees in a disturbed area.
4. Describe any variations in ratios with a second species of mangrove measured between trees in the undisturbed area to the trees in a disturbed area.
5. Propose a statement you could make about leaf ratios as indicators of disturbance to an area.
6. Justify how reliable these measurements are as indicators or suggest some other hypothesis.

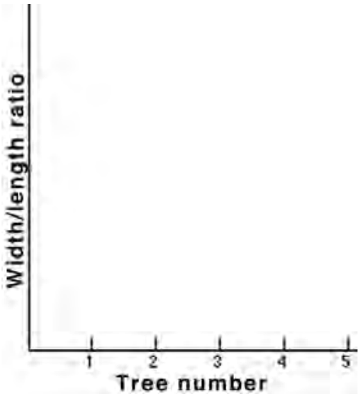


Figure 72.1 Sample graph
John Burnett

Figure 73.1 Measuring leaf/width ratio
John Burnett

Project 2.5 Salt excretion rates

by John Burnett

A number of mangrove species in Australia are salt excretors, where excess salt is extruded from the leaves by special salt secreting cells. *Avicennia* and *Aegiceras* are two well known examples of salt excretors. The following project can be used to determine the amount of salt that is secreted by a leaf over a period of time.

You will need

- distilled or de-ionised water
- clean jar or measuring cylinder
- funnel
- salinity meter
- coloured wool

What to do

1 Identify a leaf, and tie a piece of wool near the leaf for later identification. Wash all the leaf with the distilled water to remove all salt from its surface as shown in Figure 74.1.

2. Revisit the leaf after a determined period of time (eg. two hours or one week).

   Re-wash the leaf in 10 mL of distilled water, collecting all the washing water in the jar.

3. Measure the salt content in the collected water using a salinity meter.

Analyse your results

1. Determine the amount of salt excreted from the same species of mangrove over a range of different areas (zones) using the salinity meter, eg. at sea fringe, in saturated mud, in sandy or firm ground, near the landward side.

   Compare the amount of salt excreted with these areas or zones.

2. Discuss the statement

   "*Over a period of time, changing climatic conditions, eg. hot and dry to humid condition, will influence the rate of salt excretion.*"

Figure 74.1 Washing mangrove leaves to collect salt
John Burnett

Figure 74.2 Salinity mete
John Burnett

Chapter 3 Ecology and succession

by Dave Claridge

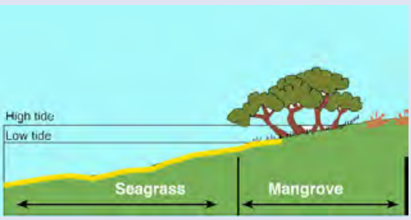
Figure 76.1 Some mangroves can use cable roots close to the surface to anchor the plant and to aid aeration

Zonation

Semeniuk, Keneally and Wilson (1978) made a number of observations on zonation:

Full zonation occurs only in tropical humid climates associated with rainforests such as in north Queensland or South east Asia; full zonation is actually quite rare.

With reduction in rainfall, flats clothed in succulents such as samphire and salt couch may replace or enter the landward fringes. In areas of reduced rainfall Bruguiera may be reduced to isolated trees, or even disappear.



Zones of different types of mangroves can often be seen in a mangrove environment

Ecological succession

Zonation

One of the most unusual features of a mangrove forest is the development of bands of dominant species which run roughly parallel with the shoreline or the banks of tidal creek systems.

There have been a number of reasons advanced for this phenomenon: one suggests that zonation is no more than a progression of pioneer species towards those which are less tolerant of salt, thus leading eventually towards the formation of terrestrial forests.

Another suggests that zonation depends upon the salinity of the substrate, with tidal inundation as only a secondary element.

Yet another theory was that zonation is related to the size of the mangrove seeds, large seeds cannot take root over the landward fringe because the water is not deep enough, and that small seeds disperse widely but can take root only in shallow water.

Over time, all these hypotheses have failed because none have taken into account the range of other factors involved.

Macnae (1968) recognised a recurring pattern of mangrove distribution based on height above mean sea level when he distinguished the following zones:

1. The Landward fringe
2. *Ceriops* zone
3. *Bruguiera* zone
4. *Rhizophora* zone
5. Seaward zone

The height above mean sea level is not the only physiographic determinant of zonation: others include the elevation and scope of the mangrove forest floor and the amount of fresh water run off. These factors, together with the tidal range, determine the duration and degree of tidal inundation.

The relationship between tidal influence and the surface of the mangrove forest floor involves other factors, and has been described by Lear and Turner (1977) as a ‘tidal elevation complex’ which is a complex interrelation of drainage, water table effects, soil salinity, aeration and degree of inundation.

Climatic features such as temperature, rainfall and evaporation are important determinants of the pool of mangrove species available in any given area. Minor factors which affect local zonation might also include growth rate, seed dispersal and destruction of seedlings.

These factors suggest a slightly different zonation plan modelled on that of Macnae (1968), based on the height above sea level and degree of tidal inundation, and taking into account other physiographic and climatic considerations.

The typical mangrove forest of eastern Australia is divided into three zones:

1. The outer zone
2. The middle or main zone, which may have one or two dominant species
3. The landward zone or littoral fringe.

In southern Australia, where the number of species is limited, mangroves are found in pure stands or in mixtures in which no form of zonation is able to be recognised. In Victoria and South Australia, mangrove areas are monocultures of *Avicennia marina*.

The outer zone

This is the area which is subjected to tidal inundation at least once every twenty-four hours. Soils are soft muds and sedimentary in origin.

"Zonation...

The typical mangrove forest of Eastern Australia is divided into three zones:

1. The outer zone

2. The middle or main zone, which may have one or two dominant species

3. The landward zone or littoral fringe."

Sedimentary soils

Sedimentary soils are formed from the deposition of silts carried down rivers and streams as a result of flood run off.

First edition photo

Figure 77.1 Zonation — the outer zone. This area is commonly characterised by a row of scattered mature *Avicennia marina* on the seaward edge, behind which are dense monospecific stands of *Rhizophora stylosa*

First edition photo

Figure 78.1 The middle zone— claypan environments, as in this photo, are dominated by *Ceriops tagal, Aegialitis annulata* and stunted *Avicennia marina*

First edition photo

Figure 78. 2 The middle zone— *Aegialitis annulata*

Claypans

Soils here are also deposited as a result of settling of suspended sediments. This includes clay particles moved to the back of the zone where they are deposited. With high evaporation rates, clay pans can now form.

At the seaward edge of this region is a strip, often only one or two trees wide, of mature *Avicennia marina*. These are usually large trees and small saplings and seedlings may extend seaward of them. However these young plants rarely survive because of the harsh environment- they may be covered by mud or marine animals such as oysters or barnacles, or they may be destroyed by wind/wave action before becoming fully established.

Dense stands of *Rhizophora stylosa* are found behind the mature *Avicennia marina*. This is the major species of the outer zone.

Growing in deep mud, semi-fluid because of regular inundation, the looping prop roots of *Rhizophora stylosa* maintain a firm foothold against wind and the sea.

The middle zone

This area is subject to less regular tidal inundation — some parts may be covered only on the four days surrounding the spring tides at new and full moon.

Some soils here are also of sedimentary origin. Because of being marginally higher above mean sea level than the deeper soft muds of the outer zone, they may contain more sand and clay and be more compacted.

Dense forests of *Ceriops tagal* grow on these clayey soils. The forests are rarely more than five or six metres tall, and may be so thick as to be almost impenetrable.

This zone may also contain estuarine claypan areas which are highly saline and areas where *Sporobolus,* or salt couch, and succulents such as samphire are to be found.

In these more open spaces, stunted *Avicennia marina* is sometimes seen either as individual shrubs or in small thickets. In this environment, *Avicennia* can be quite difficult to identify. Careful study of the leaf colour is necessary as well as a search through the ground cover for the distinctive pneumatophores.

On the higher, less saline soils *Bruguiera gymnorrhiza* is found. These are easily identified by their prominent knee roots and very large leaves. In north Queensland they may form luxuriant forests up to 30 metres tall, and in places merge with the littoral forest (Lear and Turner 1977). In more temperate areas, stands of *Bruguiera* are neither as tall nor as dense. Throughout most of its range *Bruguiera* is regularly associated with *Xylocarpus granatum* which occurs as far south as the Mary River in Queensland.

The landward or littoral zone

This area is only rarely inundated, generally on the higher spring tides. It is usually a narrow strip, and may merge into woodland or rainforest.

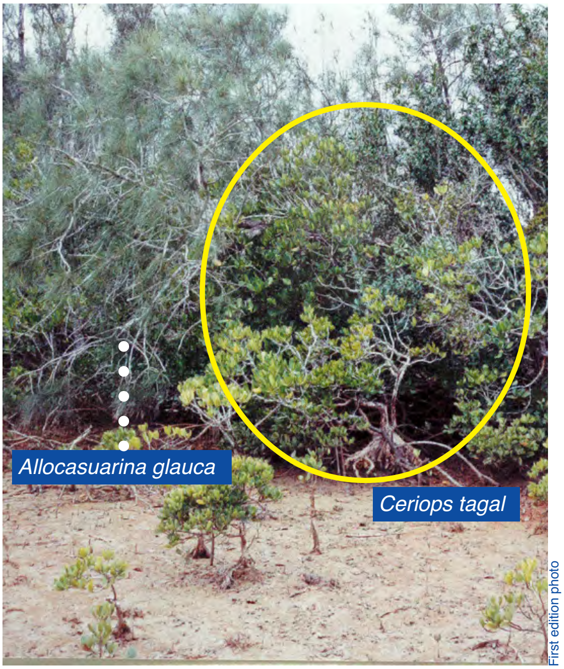


Figure 79.1 The littoral fringe — claypan on which *Ceriops tagal*, the dominant species, backs onto a forest of *Allocasuarina glauca*. Within this small region are almost all the mangrove species of that area.

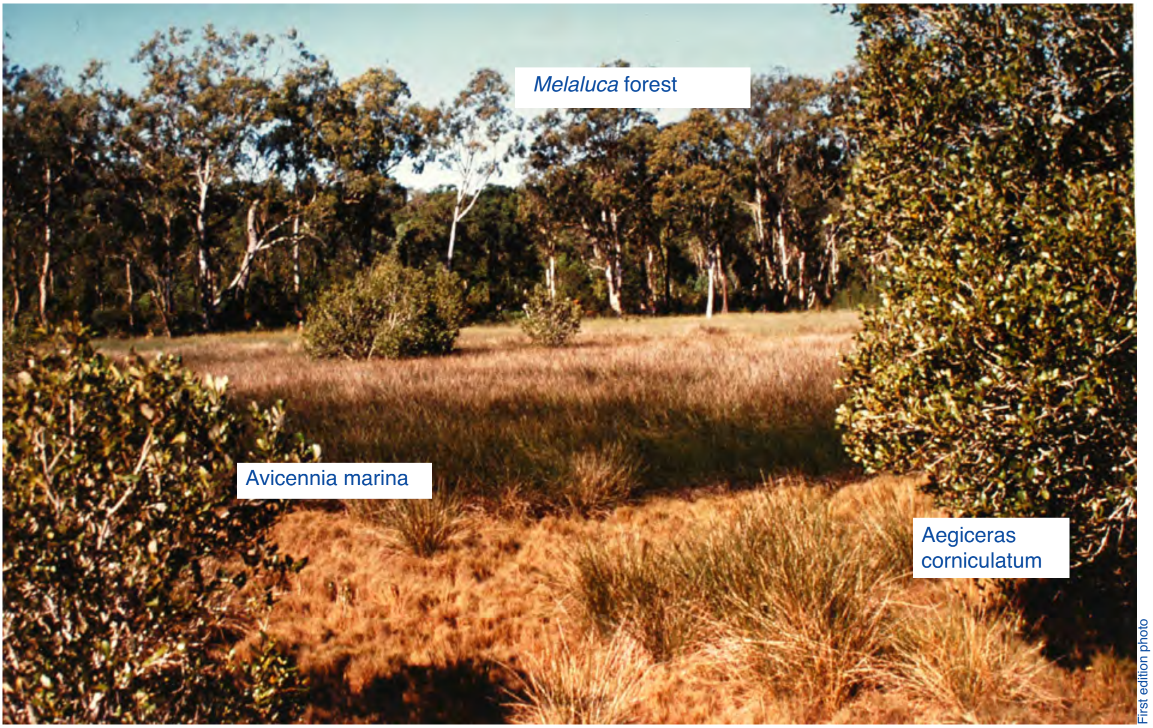


Figure 79.2 The littoral fringe — a wetland area with *Avicennia marina* and *Aegiceras corniculatum* backing onto open *Melaluca* forest.

Figure 80.1 The littoral fringe. In this example, the mangroves back on to a rainforest. Note the remnant of an earlier beach, the presence of *Ceriops tagal* and *Aegiceras corniculatum* in the rainforest margin. *Microsorium* ferns are common to rainforest margins all along the eastern coast.

"Concentrations of mangroves...

The greatest concentration of mangrove species is normally at the mouth of tidal creeks and rivers where the influence of fresh or brackish water is least, and there is greater variety in the substrate available for colonisation.

There is also a greater area of banks built up as a result of flood deposition..."

In tropical regions this zone may contain representatives of most species to be found in the area. However in more temperate parts where the rainfall is less, four species are usually found: *Avicennia marina, Aegiceras corniculatum, Excoecaria agallocha* and *Lumnitzera racemosa*.

Two terrestrial trees regularly appear on the landward edge of the littoral zone. These are *Allocasuarina glauca*, the Swamp she oak, and *Hibiscus tiliaceus*. Both these species have very high salt tolerance. Wightman (1989) and Clough (1982) have both classified *H.tiliaceus* as a mangrove. In some of the wetland areas of southern Queensland *C.glauca* can be observed growing alongside *Excoecaria agallocha*.

The greatest concentration of mangrove species is normally at the mouth of tidal creeks and rivers where the influence of fresh or brackish water is least, and there is greater variety in the substrate available for colonisation. There is also a greater area of banks built up as a result of flood deposition.

Mangrove populations decrease upstream and only two species — *Avicennia marina* and *Aegiceras corniculatum* — are found as far as the limit of tidal influence. It has been reported that these two species, together with *Acanthus ilicifolius*, are the only ones which will stand extended flooding by fresh water.

Mud - an abiotic factor

Below the surface, the black oxygen-deficient mud is very stable.

The mud is full of nutrients, consisting of partly digested smaller matter left after decay on the surface and percolates deep into the mud. The anaerobic bacteria (which can live without oxygen) use the smaller particles as a food source.

Anaerobic bacteria have the ability to use sulphate from the sea water as their main energy source creating an environment rich in hydrogen sulphide.

This hydrogen sulphide is either poisonous to the organisms or can be used as an energy source by others through chemosynthesis. The areas with the high levels of hydrogen sulphide are usually barren of larger organisms, usually due to the poisonous nature of the gas.

In areas with no hydrogen sulphide present and where the sediment is coarser, crabs, mud whelks (Figure 81.1), shrimp, worms and burrowing molluscs can be found. These areas are more suited for digging and burrowing and so these animals will generally avoid areas with high hydrogen sulphide gas concentration. In addition, the mangroves that live in these areas all have a type of breathing root to obtain the oxygen required.

Figure 81.1 Mud whelks

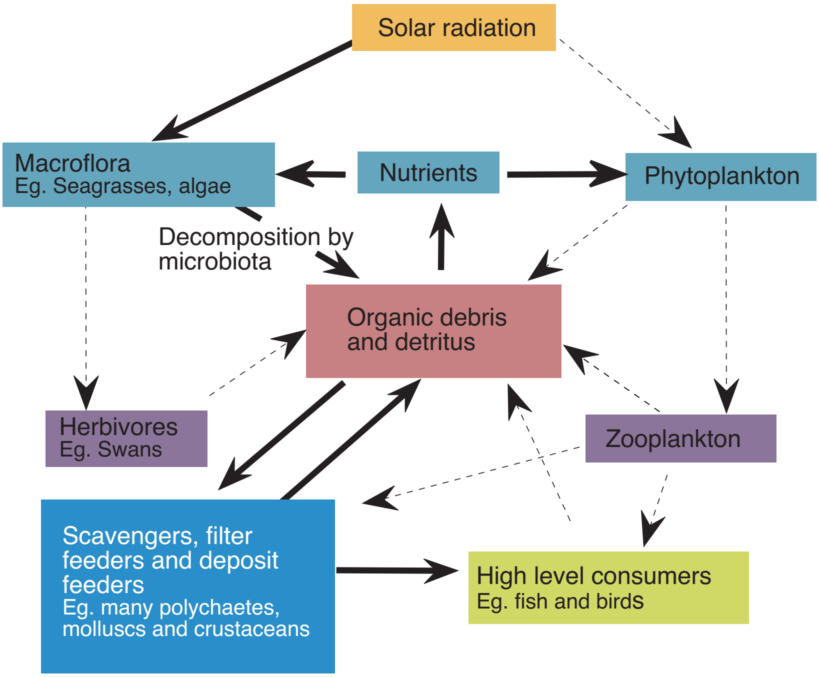


Figure 81.2 Estuarine feeding relationships (after Operculum 1982)
Reproduced with permission by Australian Littoral Society .

Figure 82.1 Mangrove mud at low tide

The ability to tolerate hydrogen sulphide and not be poisoned is a great advantage to the bacteria because the larger organisms that feed on them, or compete with them cannot survive in this hostile environment.

This means that larger populations may be able to develop and grow in this environment.

Sulphur bacteria, such as *Beggiatoa*, require oxygen, carbon dioxide, water and hydrogen sulphide as the primary energy source for growing.

This 'growing process' called chemosynthesis, produce carbohydrates and a white to pale yellow element sulphur becomes visible as an end product of the process.

This process can only occur at the boundary at or near the surface where both hydrogen sulphide and oxygen are available, and *Beggiatoa* will constantly move in search of this boundary.

This is a diurnal movement where the bacteria move to the surface when the oxygen is used at night and move down into the mud during the day when oxygen is produced by photosynthesis.

An area where the sulphur bacteria are present (indicated by the white to pale yellow or pink colour on the mud) is an area that is devoid of the distinctive odour of hydrogen sulphide.

Nitrogen cycle

Another essential group of micro-organisms are those involved in the denitrification within the flooded anaerobic soils and mud of the mangrove environment. The microbes can cause massive losses of nitrogen from the system, with the starting point being ammonia.

The ammonia, which is usually located in the anaerobic zone of the soil, will diffuse up toward the aerobic zone.

At this stage the ammonia is oxidised by bacterial action to a nitrate, and moves back to the anaerobic zone, where it is reduced by other bacteria to nitrous oxide and nitrogen gas (Boto, in Clough,1982).

The gases are then able to rapidly diffuse out of the mud and into the atmosphere.

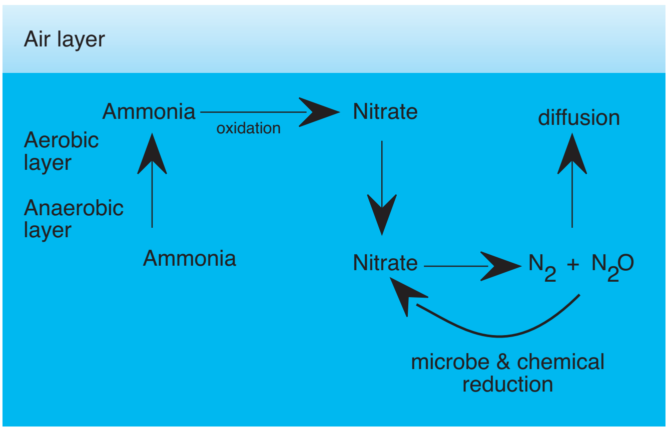


Figure 82.2 The nitrogen cycle (after Boto, in Clough, 1982)

Mangrove food chains

Mangroves, like all other plants, use photosynthesis to convert sunlight to plant tissue, and so become a food source for animals.

However the basis of the mangrove food chain is not the mangroves themselves, but the leaf litter.

When the mangrove leaves fall they, together with other vegetable matter such as bark, fruit, etc, decompose under the attack of bacteria and fungi.

Soluble nutrients are released into the tides and the soil to become nutrients for algae, plankton, and for the mangroves themselves.

The decomposed leaf particles (detritus) become the direct food source for crabs and both juvenile and adult prawns.

Numerous species of zooplankton depend upon this vegetable protein as a food source also.

A few species of adult fish, notably garfish and mullet, graze directly on the leaf fragments, however up to 80% of the mangrove litter is recycled through detrital breakdown.

The crop of mangrove litter averages about 18 tonnes/ha/year (Bunt 1981). In southern states, the figure is much less—the further north, the greater the crop.

The conversion of this to usable protein makes the mangrove forest the richest zone of natural agriculture in the world, richer by far than rainforest, and certainly richer than coral reef.

With the possible exception of sugar cane farming, the return of protein per hectare is better than human farming

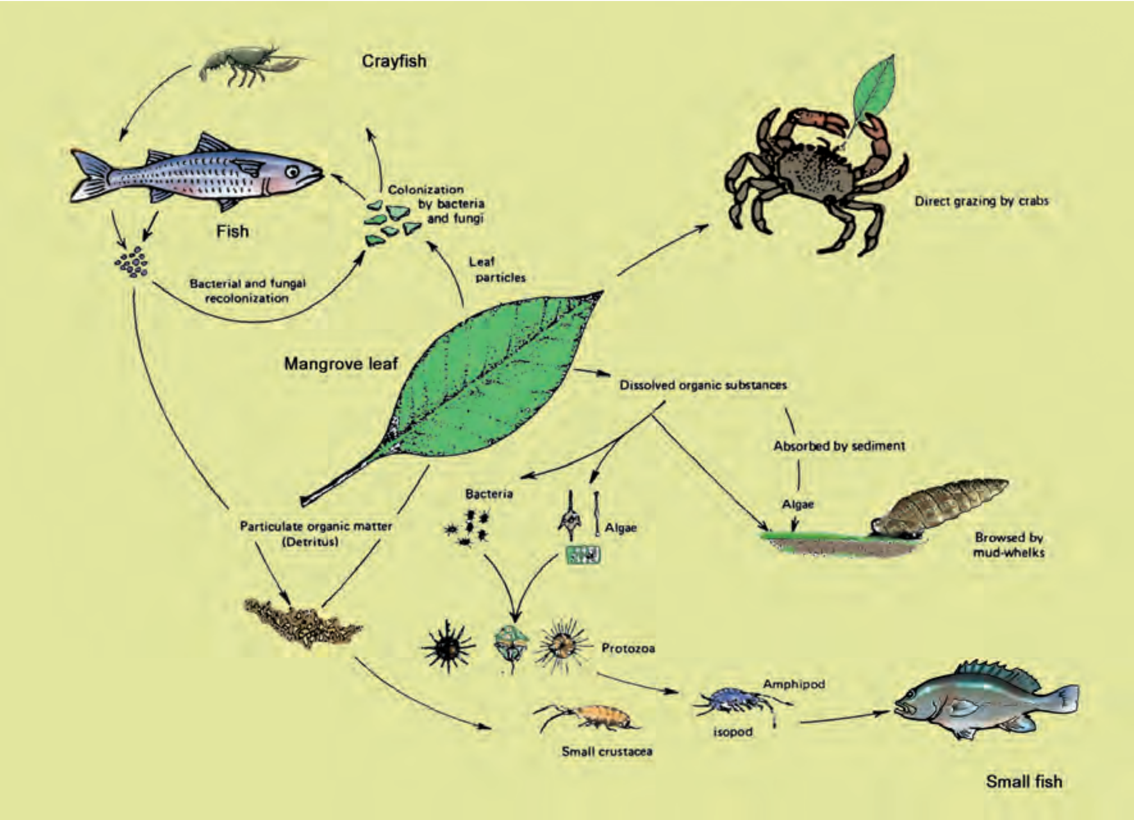


Figure 83.1 Mangrove food web (after Lear and Turner 1977)

Sharon Madder

Type of tree	Leaves Shape, size, colour	Roots	Special features

Figure 84.1 Observation sheet

Bob Moffatt

Figure 84.2 Dissolved oxygen probe

Field trip: Mangrove adaptations and relationships

You will need

- Excursion clothing for a mangrove swamp of your local area
- Two person kayak and safety equipment
- Camera and waterproof bag
- Small notebook and pencil
- Computer with simcard reader
- A permit to collect mangrove leaves and small zip top bags
- Jars to collect mud
- Salinity and dissolved oxygen probes
- Other water quality test equipment as determined (see page 121)

What to do

Prior to the trip

1. Revise the scientific concepts of *mangrove adaptations and relationship* so you can distinguish between structural, functional and behavioural variations and know the difference between producers, herbivores, predators, scavengers and decomposers when looking for them in the field..
2. In your pocket notebook make a list of photographs that need to be taken,.
3. Go out in a kayak with your partner and practice taking photos, returning to school and then processing them.
4. Study the tides, weather patterns, find out about local currents and plan a trip to the mangroves so you paddle into the tide on the way out and drift back.

At the shoreline

1. Take photographs of
    - mud and animals living on it
    - different types of mangroves
    - mangrove leaves, fruit and flowers (if possible)
    - other plants found in the area
    - bird, spiders and bugs in the trees
    - snails, shells, oysters on the mangrove roots
    - anything else (rubbish, slime, people fishing, crab pots etc)
2. Collect a sample of mud and set up a field laboratory to complete exercises 3.1, 3.2 and 3.3.
   Record your data for
   - Mud salinity and porosity
   - Dissolved oxygen
3. Store a separate sample of mud in a jar (see page 87) for analysis back at the lab.
4. Complete other water quality tests as determined (See page 121) Example: pH, nitrate, nitrite, turbidity etc.
5. Completing an observation sheet similar to the one shown in Figure 84.1.

On the kayak trip

1. After you have completed all the necessary safety and WH&S drills take a good look around at the mangrove area and plan a one hour paddle.
2. Make sure you have photographs of the
   - shoreline
   - birds or birds on the bank
   - seagrass (if the water is clear)
   - life on mudbanks
   - human impacts (eg walls, stormwater outlets)
   - anything else as identified in your plan

Figure 85.1 Mangroves are easy to access from a kayak

After the trip

Organise the files on your computer by setting up three folders called adaptations, relationships and human impacts. Now select photograph files, rename them and place them in the folders.

Analyse your results

1. Account for difference in anatomical, physiological and behavioural adaptations in mangroves using photographs to justify your answer.
2. Draw up a data table to summarise your mud salinity, porosity and dissolved oxygen data.
3. Draw up and complete the table shown in Figure 85.2.
4. Summarise your understanding of the following two ecological statements identifying the individual animals and plants from your field work in a two page discussion.

For a Kayak trip you will be required to complete ALL the necessary school workplace health and safety procedure. If this is too onerous, obtain an old pair of shoes and do the trip in the mud at low tide.

A good reference is our Marine Science flipbook pages Chapter 15, pages 394-407

Ecological statement 1:

"The interactions of marine organisms with the abiotic factors of mud salinity, dissolved oxygen and mud porosity impacts on mangrove adaptations"

Ecological statement 2:

"The interactions of other plants, herbivores, predators, scavengers, decomposers and human impact on mangrove adaptations".

Producers	Herbivores	Predators	Scavengers	Decomposers

Figure 85.2 Food web table

Lab exercise 3.1 Mud salinity

by John Burnett

Aim

To find how the salt gradient changes in a transect line from the waters edge in the mangroves and through into the wetland area.

The salinity of the mud will vary throughout the mangrove environment, and the variation will be due to the amount of water inundation and the temperature variations in the region.

You will need

- mud samples from a variety of transect points in a mudflat
- salinity meter or salinity chemical test kit
- electronic scales

Method

- To find the salinity of the mud (or soil in the wetlands behind the mangroves), the standard test is to put one part of soil or mud to five parts of distilled water into a container and shake.
  This method will dissolve out all the salts in the soil.
- Test the salinity using a salt meter or allow mud to settle and use the minititration method to determine the salt content.
- Test the mud or soil sample from mud for every five or ten metres.
  You can either test the samples in the field or back in the laboratory.

Analyse your results

1. Describe and evaluate your research methods.
2. Draw a profile of the area and draw a graph showing the changes in salinity with distance (salinity gradient).
3. Compare mud samples from different parts of the transect and suggest reasons for differences. You may want to combine this with soil type.

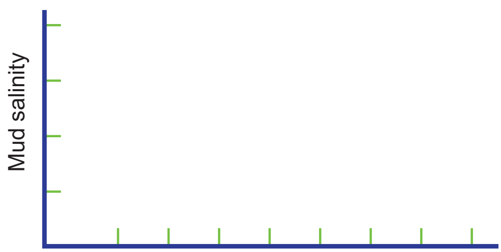


Figure 86.1 Measuring mud salinity with a salinity meter

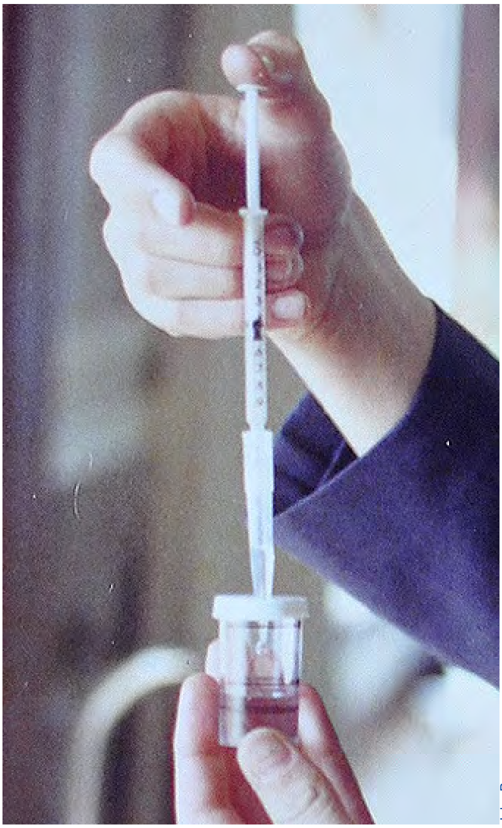


Figure 86.2 Measuring mud salinity with the minititration method

Lab exercise 3.2 Organic component of the mud

by John Burnett

Aim

To determine the amount of organic matter in a mud sample.

You will need

- crucible
- hot plate or bunsen burner
- electronic scales

What to do

1. Collect a mud sample and dry it completely (sun dry or in an oven).
2. Accurately weigh the crucible. Record the weight.
3. Place exactly 20 g of the dried mud sample into a crucible.
4. Heat strongly on the hotplate or with the burner until all the organic material has been burnt.
5. Allow the remains to cool and re-weigh the sample in the crucible.
   Deduct the weight of the crucible to get the new weight of the sample (residue).
6. Calculate the total amount of organic matter in the mud using the following equation: dry weight of mud — weight of residue. Record your results.

Analyse your results

1. Calculate the percentage of organic matter in the mud sample.
2. Look at any remaining sample. Determine the composition of the organic matter in the mud.
   Suggest where this organic matter comes from.
3. Explain the importance of organic matter to all the animals in the food chain.

John Burneyy

Figure 87.1 Chemosynthesis by sulphur bacteria in a mud sample can be seen as the white area.

Lab exercise 3.3 Mud porosity and dissolved oxygen

Aim

To determine the rate of saturation of different sediments you need to do a water flow test.

You will need

- funnel
- cotton wool
- retort stand and clamp
- conical flask
- stopwatch.

What to do

Mud porosity

1. Place a small wad of cotton wool in the funnel and half fill with fresh mud or sediment to be tested.
2. Pour 100 ml of water into the funnel and time how long
   a) before the water starts to flows through
   b) for all the water to flow through the sediment.

Dissolved oxygen (need to be done in the field)

1. Locate a mangrove pool.
2. Use the probe to measure the dissolved oxygen.
3. Wade out as far as you can and measure the DO level in main stream.
   Record your data.

Analyse your results

1. Draw a data table to record your results.
2. Compare and contrast which sediment is most porous, most saturated and best at holding water.
3. Compare dissolved oxygen levels at different places.

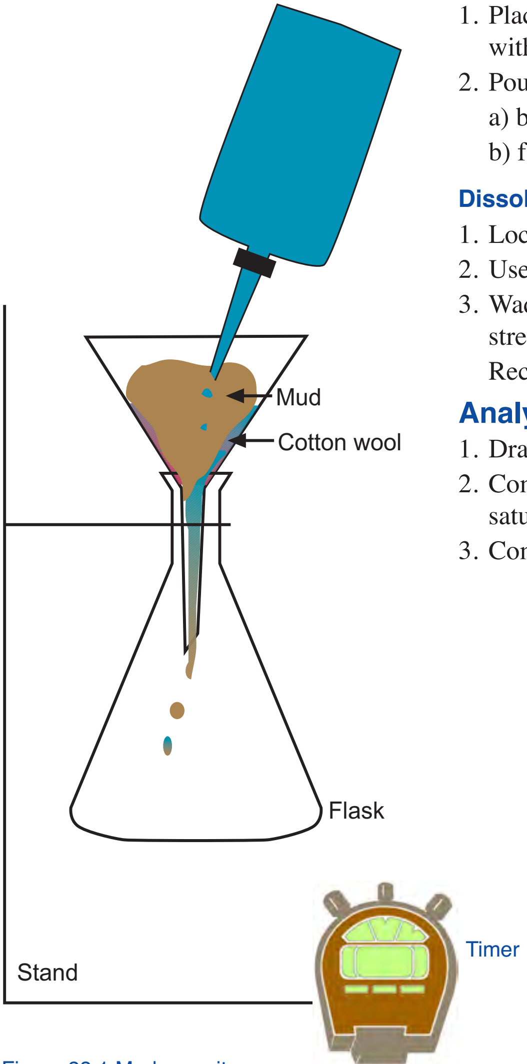


Figure 88.1 Mud porosity
Bob Moffatt

Project 3.1 Mangrove productivity

by John Burnett

Part A

The amount of productivity of the algal mat (a concentration of algae that covers the mud, logs and pneumatophores in the mangrove environment) can be determined by the amount of oxygen produced in a given amount of time.

You will need

- 10 mL measuring cylinder
- glass funnel
- watch

What to do

1. Place the funnel on a piece of algal mat in a pool of water.
2. Fill the measuring cylinder with water and place over the funnel.
3. Leave for a period of time, eg. 30 minutes.
4. Now measure the volume of oxygen produced.

Analyse your results

To determine the rate of production of oxygen in the area:

1. Record the volume of oxygen in the measuring cylinder
2. Calculate the area of algae under the funnel ($A = \pi r^2$).
3. Calculate the volume of oxygen produced per hour/ m^2.
   Try a range of different locations, different surfaces and different amounts of sunlight.
4. Write a report estimating the productivity of a variety of areas.

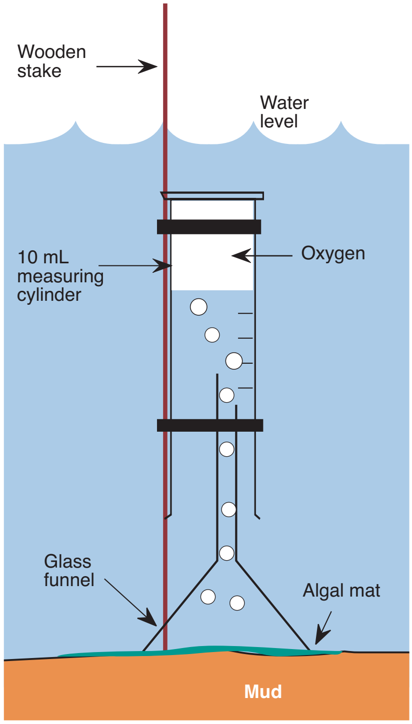


Figure 89.1 Measuring productivity in the mangroves
Bob Moffatt

Part B

The algal mats of the mangrove mud are grazed by both snails and crabs.

Find how important the algae are to the other organisms as an energy source.

Compare grazed and ungrazed areas of mud.

In order to control the grazing comparison, make some exclusion cages as shown in Figure 89.2.

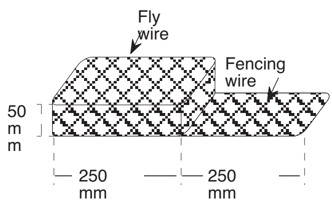


Figure 89.2 Mollusc exclusion cage
Bob Moffatt

Rationale

You are to study the succession of plants from inland forest to tidal forest.

Study sites are selected at each change in the community to ascertain changes in abiotic factors affecting plant growth.

Project 3.2 Ecological succession

by John Burnett

What to do

1. Use local experts to select a suitable study site for this exercise.

   A common succession could be shown as follows:

   Eucalypt forest → Melaleuca forest → Casuarina forest → Salt marsh → Mangrove forest

2. In this area you will study the change in vegetation as you move from inland forest to the sea. A number of different zones should be apparent. At each change in vegetation conduct a study of the area.
3. Measure out a 10 m quadrat and record the information detailed in Table 90.1 below.
4. With the information gained in each area you should be able to explain the progressive change in vegetation.

   Give each zone a name based on the dominant type of vegetation or some other obvious feature.

   - At least five zones should be obvious.
   - An example is given on the next page.

Table 90.1 Variable/zonation table

Variable		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Major plant types						
Other plant types						
Light intensity						
Soil type, colour,texture moisture						
Percent ground cover						
Soil	Salinity					
	pH					
Temperature	Air					
	Soil					
Relative humidity						
Animals present						
Wind velocity	1 m above ground					
	canopy level					

Analyse your results

1. Draw a vegetation profile of the succession. Include only dominant species.
2. Refer to your key to identify plant type.
3. Explain the changes in vegetation as you move from inland forest to the sea.

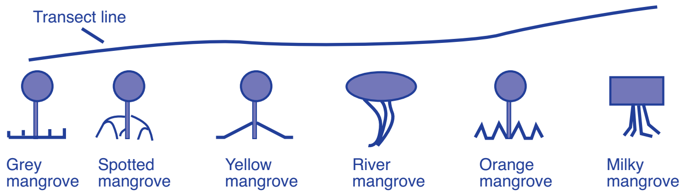


Figure 91.1 Profile suggestions

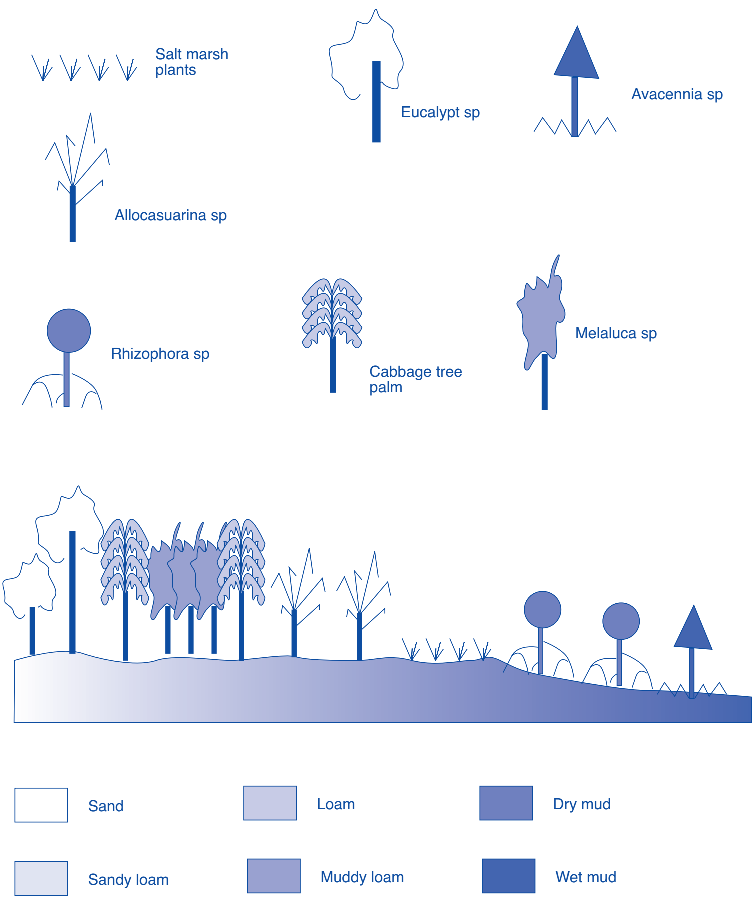


Figure 91.2 Vegetation profile (Example)
Bob Moffatt

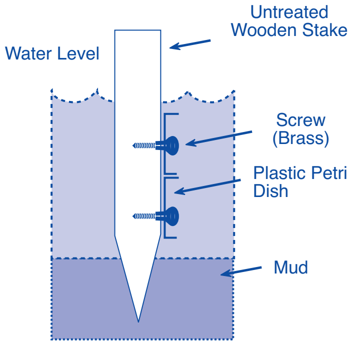


Figure 92.1 Plastic petri dishes can be used to collect organisms for later study
Bob Moffatt

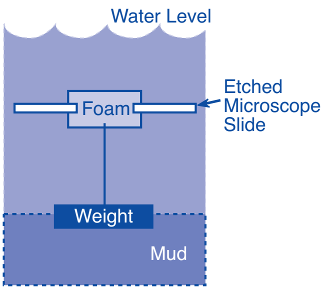


Figure 92.2 Etched microscope slides for easy removal for study later
Bob Moffatt

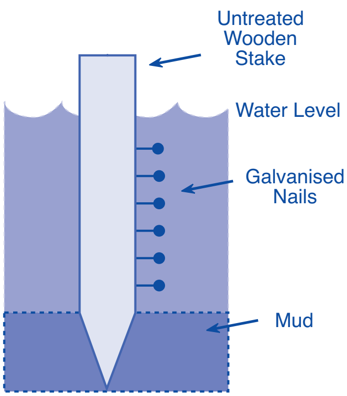


Figure 92.3 Galvanised nails used to collect marine organisms. Based on some ideas by B. Brock
Bob Moffatt.

Project 3.3 Investigating attaching organisms

NOTE: This is a long-term project.

by John Burnett

Many organisms enter the mangrove environment as a planktonic form and then settle onto rocks, logs, mud, tree trunks and branches.

These organisms then grow in this nutrient rich environment, often completely covering the surface they settle on and becoming a major part of the mangrove ecosystem. These same organisms may cover jetties or the bottom of moored boats. They are known as fouling organisms. Examples of organisms found in this ecosystem include algae, bryozoans, barnacles and oysters.

You will need

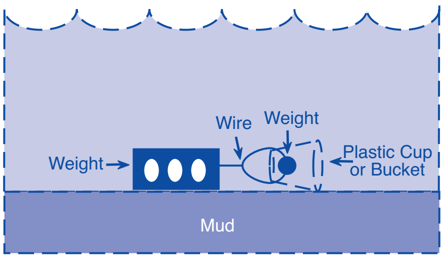
- sampling equipment as shown in Figures 92.1 - 92.3 and 93.1 over.
- microscope
- cover slips and slides
- petri dishes

What to do

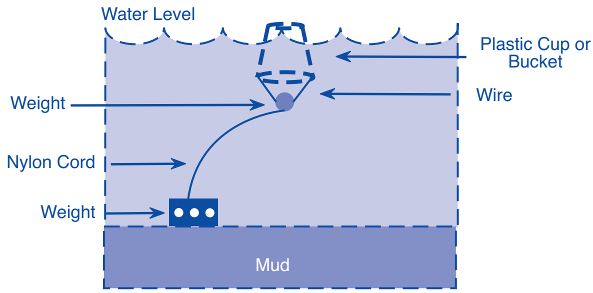
Read the stages of settlement information box on the next page.

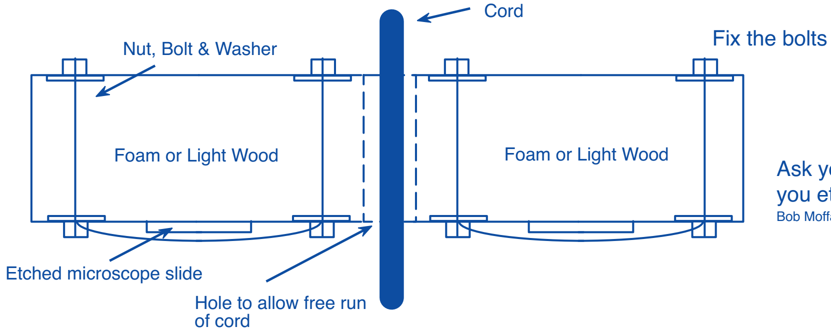
1. These organisms can be collected and observed if the sampling apparatus (as shown in Figures 92.1 to 92.2) are left undisturbed at sites in the mangrove environment. The best results occur if the apparatus is left in a permanent water body such as in pools or in creeks within the study area and data recorded every week.
   Turn over two pages to look at other methods of collecting marine organisms.
2. A marked stick can be used to find the zonation within the mangrove area, as can the multi-level sampler. The other devices that are illustrated can be used to collect these organisms at a specific depth or on the bottom of the water body.
3. There are three methods of obtaining samples for microscopic analysis.
   a. Scrape a sample into a cavity slide, add a drop of sea water, place on a cover slip and observe.
   b. If using an etched slide, make a ring of wire (use a paper clip) and place in a petri dish. Place the slide on the wire and cover with sea water. Observe under a microscope.
   c. If using samples collected on a petri dish, plug the hole with 'Blu-tack' and add enough sea water to cover the organisms. Observe under a microscope.

Sampling for Fouling Organisms on the Bottom



Sampling for fouling organisms on the Surface





Ask your teacher how do you etch a microscope slide
Bob Moffatt

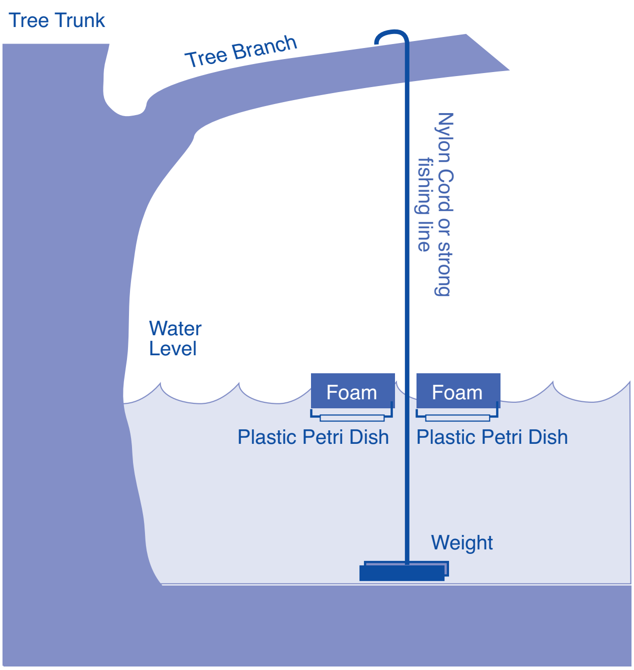


Figure 93.1 Techniques for collecting marine organisms that attach
Bob Moffatt

Analysing your results

This is an open ended project over many weeks so draw up data tables like the one in Table 94.1 for each week recording the population density and organism present.

1. Identify and calculate population densities for the organisms you find.
2. Compare your settlement patterns with the information box above contrasting differences.
3. Evaluate your research methods suggesting improvements.

Stages of settlement

The settlement process happens in two stages: settlement fouling and secondary settlement.

Primary settlement organisms are usually bacteria/fungi/algae and protozoans. Silt also begins to settle in this phase. These organisms have a direct, little-understood impact on the future settlement of secondary fouling organisms. However, if the primary settlement organisms can be controlled then the secondary settlement organisms will also be controlled. Secondary settlement organisms are larger organisms, for example, barnacles, oysters, weeds, worms, etc.

The usual order of settlement is from plants to animals and happens as follows:

- Days 1 to 3 — bacteria/detritus
- Days 4 to 5 — diatoms
- Day 7 — protozoans
- Days 8 to 14 —hydrozoans
- After 2 weeks — barnacles, oysters, serpulid polychaete (calcarious tubes)

  The type and number of the dominant organism changes depending on the time of the year and or location

Table 94.1 Sample site results

Date	Organisms found	Population density/sq cm	Dominant or non dominant

Project 3.4 Mangrove leaf decomposition rates

by John Burnett

Decomposition is constantly occurring in the mangrove environment, with a variety of bacteria being the main organisms involved. The rate of decomposition can be measured over a period of time (this may take two or three weeks).

You will need

- filter paper
- nylon fly wire
- fishing line
- sewing needle
- piece of coloured cloth

What to do

1. Cut the filter paper to obtain a square 100 mm x 100 mm.
2. Mark the paper into 10 mm squares.
3. Make a pouch of fly wire and place the filter paper inside. Now sew up the pouch (Figure 95.1).
4. Tie a length of fishing line to the pouch and then bury the pouch and paper in the mud. Tie the other end of the fishing line to a tree and mark with the coloured cloth marker.
5. Examine the filter paper square every two days if possible and estimate how much of it has decomposed. Continue to observe and record the results until all the filter paper has decomposed.

Analyse your results

1. Complete a table recording the area of each sample that has been removed by decay, and calculate the percentage. Draw a graph of the data from the table (Figure 95.2).
3. Explain the trend shown by the graph.
4. Explain what has happened to the paper.
5. Suggest a chemical equation to explain the process of decomposition.

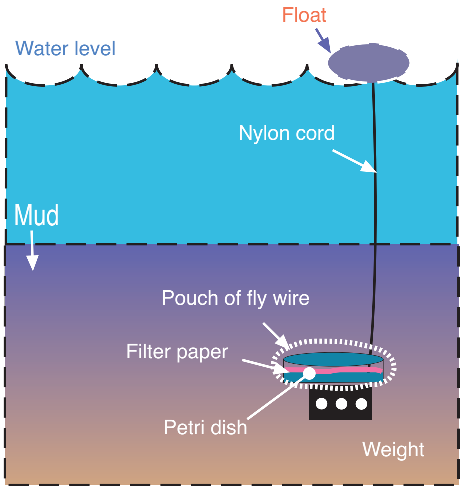


Figure 95.1 Mangrove decomposition project

Bob Moffatt

Extension ideas

- *You may wish to try different areas in the mangrove, and some areas with different compositions of mud and sand. Try areas with different amounts of soil saturation.*
- *Place different natural substances into the pouch (e.g. cotton, cloth, wool, silk, linen etc.) and compare rates of decomposition.*
- *Calculate the area of a mangrove leaf, bury it in a pouch and determine the rate of decomposition. Compare rates of decomposition of a range of different mangrove leaves for a given area.*

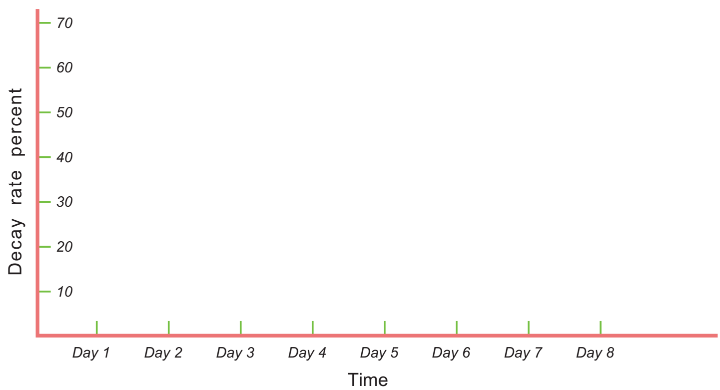


Figure 95.2 Data analysis

Figure 96.1 A piezometer
John Burnett

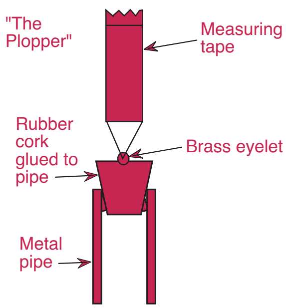


Figure 96.2 The plopper
Bob Moffatt

Project 3.5 Mud saturation

by John Burnett

Background

- To test the amount and depth of the water flowing through the mud and sediment you will need to construct a piezometer.
  This device can be placed in the mud and used for long term measurements of the water levels in the substrate.
- If a series of piezometers are placed in a line, spaced a set distance apart, it is possible to accurately plot the saturation of the subsoil in a given area.

You will need

- 500 mm length of 60 mm to 80 mm PVC pipe
- two PVC caps to fit (one cut half way with a hacksaw)
- hacksaw
- 80 mm length of metal pipe
- cork to fit metal pipe
- brass eyelet and metre rule
- measuring tape
- wooden stake and hammer
- spade, landscape aggregate, sand

What to do

Part A: Construct the PVC and plopper components

1. Firmly place the cap over one end of the PVC pipe.
2. Cut a series of slits into the PVC pipe, for approximately one third of the pipe (see Figure 96.1).
3. Now take the metal pipe and insert the cork. Fix the eyelet to the cork and attach the tape Remember that the bottom of the pipe plopper is marked zero. (see Figure 96.2).

Part B: Determine the study site's characteristics

1. Take the wooden stake and drive it into the mud with the hammer.
2. When it will not go in any further, remove from the mud and measure the distance that the stake penetrated into the mud.
3. Try to find the penetration depth of a number of other sites with different amounts of wetness on the surface

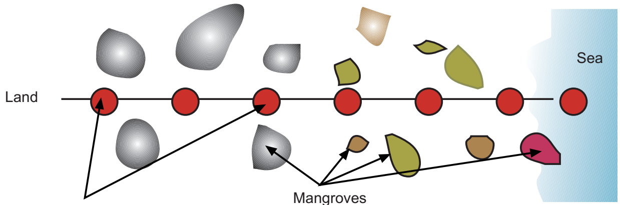
This shows the amount of water flowing through the sediment, and also the distance the ground water is below the surface. This relates to the amount of saturation of the mud.

The information obtained from a line of piezometers could be used to plot the depth of ground water in the mud from sea level to the wetlands behind the mangroves.

Samples of the underlying water can also be easily obtained for salinity measurements or analysis.

Part C: Placing of the piezometer

1. Dig a hole until you reach the water table (Figure 97.1 and Figure over).
2. Place a handful of aggregate or coarse sand into the hole, place the pipe into the hole, and surround with aggregate or sand.
3. Fill the remainder of the hole with sand and the soil from the hole.
4. Cut the PVC pipe to the appropriate length which is usually at or just above ground level.
5. Fit the loose cap i.e. the cap with the slit cut into it.
6. Allow water to fill the pipe, then measure by dropping the plumb - bob down the piezometer until it 'plunks'. Now read of the depth from the tape.
7. Use a probe to measure the salinity at the water level table. Record your results.
8. Repeat at a number of sample sites as shown in the illustration below and at spring and neap tide times.



Analyse your results

1. Determine the changes in mud saturation from sea to land over your study site.
2. Compare these with salinity at the site.
3. Contrast these values with neap and sprig tides.
4. Construct other hypothesis that this project could generate.

Figure 97.3 Analyse data with a graph similar to this

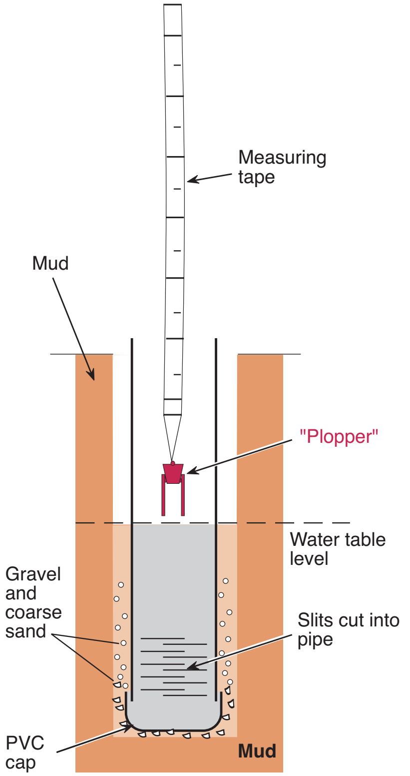


Figure 97.1 Piezometer construction details
Bob Moffatt

Figure 97.2 Using the plopper
John Burnett

Project 3.6 Pneumatophore distribution

by John Burnett

Pneumatophores are the breathing roots of some species of mangrove (*Avicennia* or *Sonneratia*). They grow to different heights and densities.

These differences can be attributed to their closeness to the sea or land, the period of time spent under water and the depth of the water.

You will need

- ruler
- 250 mm x 250 mm square quadrat grid
- tide chart

What to do

Part A

1. At the seaward side of the site use the quadrat grid square to sample the density of the pneumatophores by randomly dropping the grid into an area containing these structures.
2. Take care not to damage the pneumatophores. Count the number of pneumatophores within the grid square.
3. Repeat this process at least twice in the same area. Now calculate the average number per grid square (625 cm^2).
4. To find the number of pneumatophores per square metre multiply the average by 16. Record the density.
5. Repeat this technique with mangroves on the landward side.

Part B

1. Measure the height of at least ten pneumatophores on the seaward side and find the average height.
2. Repeat on the landward side. Record results.

Part C

1. Try to find the depth to which the two different groups of pneumatophores are covered by the tide and for what length of time.
2. Record results.

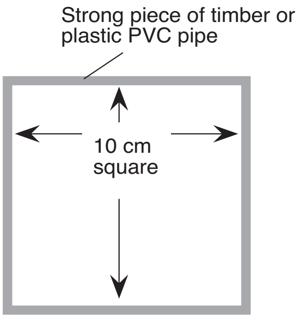


Figure 98.1 A simple quadrat
Bob Moffatt

Analyse your results

1. Draw up a table to summarise your results from Part A.
2 Compare the densities on the seaward and landward sides. Explain any differences.
3. Marine environments consist of zones, classified according to features such as availability of light and substrate composition (e.g. intertidal zone).

   Justify the inclusion of mangroves in a zone as shown in figure 263.1 of you marine science textbook.
4. Coastlines are shaped by a number of factors including movement of sediments and water. Suggest possible reasons for the formation of mud and mangrove roots.
5. Account for any evidence of ecological succession from your data.

   Draw a diagram to illustrate your answer.

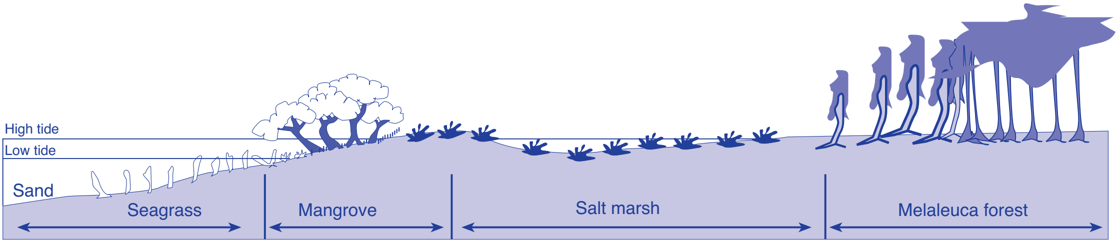


Fig 99.1 Mangrove distribution
Bob Moffatt

Project 3.7 Leaf fall and biomass

by John Burnett

This is a long term study and may need to be modified to suit local conditions and your OWN experimental design.

So don't be afraid top take the idea, run with it and change the project to suit.

You will need

- mangrove leaf net funnels (see Figure 100.1)
- lab balance
- transect line

What to do

- Read the leaf fall information box on the next page
- Make funnel nets of fine mesh that are one metre square, and set them up above the high tide mark, so that they can catch leaves, flowers and fruit that fall from the trees (Figure 100.1).
- using a set of scales (you may need some luggage scales), weigh the leaf net and frame. The idea is to be able to determine the weight of leaves collected so its up to you how to achieve this.

  Test the net on some trees in the school yard
- Map out 10 metre square quadrats at various points (every 30 m) along the transect line.
- Draw a plan view of each quadrat on your note pad. Draw a simplified profile of the transect line showing any zonation of mangroves that was evident. Use a key to represent the various species.
- Place the nets under the trees on the transect lines and after a set time (depending on the time of year) collect the nets and weight eh leaves. You may decide to re-weigh the whole net and subtract, or come up with a sub-sampling technique tat will achieve the same result.
- Collate you results in a data table like the one shown on the next page

Analyse your results

1. Describe which species of mangrove has the greatest fall.
2. Calculate the weight of biomass in the area per square metre.
3. Describe which mangrove species produces the greatest amount of biomass by weight.
4. Calculate the percentage of each type of biomass, e.g. leaves, flowers and bark.
5. Investigate how mangrove leaves are recycled by decomposers or scavengers or both. Describe the roles of each.
6. Indicate on a food web, where this recycling could occur.

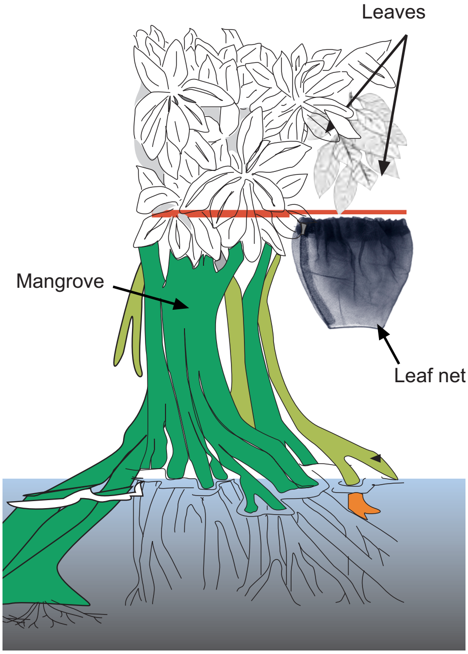


Figure 100.1 Mangrove leaf funnel net
Bob Moffatt

Dates

Location

GPS

Distance from dataum point on transect	Mangrove species	Biomass (ie weight of leaves collected)

Leaf fall

Mangroves produce extremely large amounts of organic matter through shedding leaves which then finds its way into the mud, and then into the waterways and back to the ocean.

This exercise will determine the amount of organic matter that falls over a given period of time, and the amount of organic matter found in the mud.

A mangrove study should be conducted from the low tide mark to the extreme high tide level. Quadrat studies will be done at various points.

The study can be conducted in a variety of ways. One successful method is to employ quadrat studies along a transect line.

If zonation of mangroves is important to the study then the site of the transect line must be chosen with care. Zonation tends to loosely follow height above mean sea level since various species prefer varying degrees of inundation.

Some species, eg. grey mangrove, show wide distribution while others eg. milky mangroves or orange mangroves prefer slightly higher ground. If the transect line is chosen with care, some degree of zonation should be apparent.

Project 3.8 Mangrove snail and crab populations

by John Burnett and Bob Moffatt

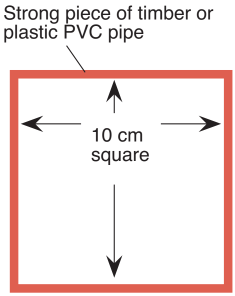


Figure 102.1 A simple quadrat
Bob Moffatt

Aim

To find the density of an organism in the mangrove forest per square metre.

Method

For snails

1. Use a 100 cm^2 quadrat (see Figure 102.1) and drop randomly in the study area.
2. Count the number of snails in the quadrat and record. Repeat this exercise at least twenty-five times.

For crabs

1. Use the method above counting the crab holes (making the assumption that each hole contains one crab).
2. Randomly place a number of quadrats over a given area and when the crabs emerge from their holes to feed, take photos of the area. Do this quietly or the crabs will retreat back into their holes.

   You may need to enlarge the photos, use slides or place the negative on a slide mount to clearly see and count the crabs. Now calculate the crab population.

Analyse your results

1. Calculate an average of the number of snails per 100 cm^2.
2. Now calculate how many snails are found per square metre (to calculate, multiply the average per 100 cm^2 by 100). Compare these with crabs in a table.
3. Discuss the scavenger role crabs play in recycling nutrients for mangroves. Explain the significance of this process.
4. Draw up a table like the one in Figure 102.2, to compare the differences between structural, physiological and behavioural adaptations in crabs and snails.

Structural adaptations	Physiological adaptations	Behavioural adaptations
Snails		
Crabs		

Figure 102.2 Adaptations comparison table

Chapter 4 Conservation and sustainability

by Dave Claridge

Economic value of mangroves

By Dave Claridge

"Most people have held the view that a mangrove forest is a primitive, mysterious, unpleasant place with strange trees, populated by hordes of biting insects..."

Most Europeans have held the view that a mangrove forest is a primitive, mysterious, unpleasant place with strange trees, populated by hordes of biting insects, snakes, and a variety of crawling and creeping creatures: a horrible place, a waste land suitable only for the dumping of rubbish or reclamation for development. This opinion has held sway virtually since the first settlement by Europeans in 1788.

We now know of course that mangroves and wetland ecosystems really are very important, and that preservation and management of such places is vital if they are to continue to supply their many benefits to society. Let us now look at some of these benefits.

"...we now know... that mangroves and wetland ecosystems really are very important and that preservation and management of such places is vital."

Fisheries

Previously, we looked at mangrove food chains and the role which mangroves play in providing shelter for various organisms. Clearly mangroves provide shelter and food for juvenile fish of many species.

Crabs of several species, including the commercially important mud crab (*Scylla serrata*), spend most of their life cycles in the mangroves.

A number of predatory fishes spend time in mangrove areas in search for food. Many fish traditionally regarded as reef species live in mangrove estuaries as juveniles.

Figure 104.1 *Scylla serrat*a, the mud or mangrove crab, is a commercially important species of mangrove environments.

Lear and Turner (1977) stated 'Overseas studies have shown that in some coastal waters eighty percent of fish caught commercially were linked to food chains ultimately dependent on mangroves. It has been estimated that about seventy percent of fish in NSW commercial catches are reliant on estuaries for part of their life cycle'.

"... the Queensland commercial fishing industry is worth $700 million annually and provides 20 000 jobs."

As a result of a study on a mangrove environment in Moreton Bay during 1987 and 1988, R. M. Morton declared, '46 percent of the species, 75 percent of the number of fishes, and 94 percent of the biomass taken during the study... were of direct importance to regional fisheries'. He went on to say that 'our knowledge of the utilization of mangrove areas by economically important fishes is limited' (Moreton 1989).

"the mangrove environment and its associated food chains are vital to the well being of both commercial and recreational fisheries"

Surveys by senior students from Maryborough State High School at German Creek (an estuary which faces into Great Sandy Strait) during 1991 and 1992 indicated that of twenty six species taken, eighteen were of commercial or recreational fishing importance. Four of these— trevally (*Caranx ignoblis*), moses perch (*Lutjanis russellii*), snapper (*Chrysophrys auratus*) and painted sweetlip (*Plectorhynchus pictus*) — were reef dwellers as adults, but were present in the estuary as juveniles and as young adults.

A number of commercially valuable prawn species spend all or a part of their life cycles in mangroves and estuaries. In addition to direct consumption of nutrients within the mangroves, Blamey (1992) states that 'outwelling of nutrients from mangrove channels also provides a subsidy to offshore food chains'.

.."it boils down to this:

— no mangroves, no fish..."

These and other studies amply demonstrate that the mangrove environment and its associated food chains are vital to the well being of both commercial and recreational fisheries: it boils down to this — no mangroves, no fish, or very little. And make no mistake, these fisheries are very valuable industries. Consider this; the Queensland commercial fishing industry is worth $700 million annually and provides 20 000 jobs (Blamey 1992) in just one state.

Dave C;aridge

Figure 105.1 The dumping of rubbish in mangrove areas causes pollution and destruction of marine habitats.

Dave Claridge

Figure 106.1 For the recreational angler, this is a sample of species which may be caught in a typical mangrove estuary: bream, javelin fish, cod, luderick, small mulloway, threadfin salmon. Other species may include trevally, barramundi and mangrove jack.

"...Blamey (1992) suggests that the marketable value of fish from mangrove environment is equivalent to $8 380 per hectare per year."

In relation to recreational fishing, the Australian Recreational Fishing Council survey of 1984 indicated that the recreational fishery was worth in the order of $2.2 billion annually to the Australian economy. From the same survey, 4.5 million Australians go fishing each year.

Close to 600 000 Queenslanders go fishing annually (Australian Bureau of Statistics Survey 1985); nationally the recreational boating, fishing and tackle industries employ at least 80 000 people (*Courier Mail 11 December 1992*).

As a result of the study by Morton mentioned earlier, Blamey (1992) suggests that the marketable value of fish from mangrove environments is equivalent to $8 380 per hectare per year.

A pollution buffer

Despite the fact that there is legislation which protects mangroves in most Australian states, there are may sites where rubbish is dumped and effluent directly discharged into mangroves. A mangrove forest may also provide a buffer between polluted areas and nearby marine environments. In Queensland, for example, three cities which operate current waste disposal sites in mangroves are Brisbane, Cairns and Hervey Bay.

Saenger, McConchie and Clark (1990) carried out a study on a site near the dump at Wynnum (Brisbane) where a rubbish dump is separated from the sea by a mangrove forest. There is a sewage outfall adjacent to the tip site.

They found that a mangrove forest and an unvegetated saltpan between the forest and the face of the tip made a barrier preventing the movement of metallic leachates into Moreton Bay.

As a result of their chemical analysis of sediments and mangrove plant tissues it has been found that the process is as follows:

a. The mangroves reduce the speed of current and tidal flow within the forest allowing the deposition of finely grained sediments which have a greater capacity for the binding of metal than coarser grained material.

b. These sediments form an excellent habitat for the anaerobic bacteria which generate the sulphide which reacts with the metal leachate to form insoluble metal sulphides which are trapped in the sediments

c. Quantities of copper, zinc and lead may be directly absorbed by the mangrove plant.

Metals which form sulphides are trapped within the mangrove sediments. Those absorbed into the plant may later be removed from the forest, as litter containing the higher metal concentrations, is moved out by tidal flow.

The researchers also noted that this buffering effect could also be reversed, with the metals released as pollutants.

"Mangroves are able to absorb many heavy metals.."

A storm buffer

Mangroves protect coastal land by absorbing the energy of storm-driven wave and wind action — creating in effect a natural breakwater which can result in significant savings to property in the event of a storm.

"Mangroves protect coastal land by absorbing the energy of storm-driven wave and wind action."

McCristal (1974) compared the damage to mangroves after Cyclone Althea over a 160 km coastal strip — an increase in leaf litter and a few broken branches — with the damage to the esplanade at Townsville to the tune of $0.75 million.

It is interesting to note that the only two yachts to survive Cyclone Tracy unscathed in Darwin took shelter in a mangrove creek.

"It is interesting to note that the only two yachts to survive Cyclone Tracy unscathed in Darwin took shelter in a mangrove creek."

A land builder

Blamey (1992) considers mangroves are important builders of land, helping in the formation of islands and the extension of shorelines. Prop roots and pneumatophores reduce tidal flow, trapping silt and mud which results in extensive deposition. Linden and Jernalov (1980) said that 'mangroves can be seen as the pioneering species moving further and further out, converting sea to land and as proper land has been formed, handing over the land to other species'.

"... mangroves are important builders of land, helping in the formation of islands and the extension of shorelines ."

There is a body of thought that mangroves do not build land, but act only as a stabilising influence once the land has formed (Burns 1977).

Certainly as mudflats are built up, mangroves tend not to appear until the height of the flat has reached above low tide level. Whatever their exact role, mangroves play an important part in land building.

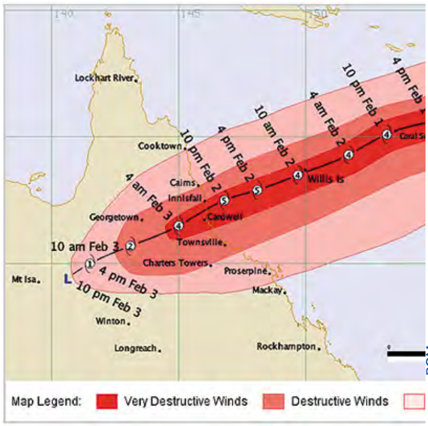


Figure 107.1 Cyclone Yazi

Simone Baker

Figure 108.1 Australian recreational fisher

A range of recreational opportunities

The list of recreational activities which may be undertaken in mangrove and wetland areas is quite extensive — boating, fishing, wildlife observation, and photography to name but a few. A telephone survey conducted by the Centre for Coastal Management (CCM) in 1990 indicated that 44% of the respondents had visited wetlands within the Brisbane City area (Blamey 1992).

The beekeeping industry

Beekeepers have long regarded mangroves a major source of honey, especially *Aegiceras corniculatum*. Mangrove honey is very pale, and is regarded by many as the purest of all.

Aboriginal usage

Coastal Aborigines in northern and eastern Australia have close ecological and cultural links with mangroves which provide them with many useful resources. A full list is quite extensive and could be divided into three groups: food, medicinal and weapons and implements. The following are just some examples.

Food

many species are useful as a source of honey. The fruit of *Avicennia, Nypa* and *Bruguiera gymnorrhiza* can be eaten after careful preparation.

Medicinal

Crushed leaves of *Osbornia* are used as a remedy for toothache or an insect repellent. Ashes and bark infusions from both *Ceriops* and *Avicennia* have been used to treat skin disorders and sores, including leprosy. The latex from *Excoecaria* has been used to treat marine stings; the inner bark of *Hibiscus tiliaceus* is used to treat headaches and boils.

Weapons/implements

Throughout northern Australia, timber from *Ceriops, Rhizophora* and *Bruguiera* has been used for spears, boomerangs. The use to which *Scyphiphora hydrophylacea* is put to is indicated by its common name - yamstick mangrove.

The sap of *Excoecaria* has been used to stupefy fish, as has *Derris trifoliata,* a climber which is often associated with *Avicennia marina* or *Hibiscus tiliaceus*.

Use in other countries

Mention was made in the introduction to this book of the value which may be placed on mangrove wetlands in the United States.

Apart from its value to recreational fisheries and eco- tourism, Florida's wetlands support an US$18 million shrimp fishery (Gore 1977).

Bob Moffatt

Figure 108.2 Asian seafood

In the various countries of South-east Asia, links with mangrove ecosystems have always been close, and a wide variety of uses have been recorded (Lear and Turner 1977, Field and Dartnall 1987). Some of the medicinal uses include:

- *Acanthus ilicifolius* - a leaf preparation is used for treating snakebite, rheumatism
- *Ceriops* sp- a bark extract is used to treat haemorrhage, even in obstetrics
- Sap of *Excoecaria* has purgative properties
- An extract of leaves from *Lumnitzera* sp is used as a treatment for thrush
- Seeds of *Heritiera* relieve diarrhoea.
- The bark from *Ceriops*, *Rhizophora, Bruguiera* and *Aegiceras* is used for tanning.
- Dyes can be extracted from *Cynometra, Ceriops* and *Xylocarpus*.

Various mangrove timbers have a multiplicity of use throughout the region, including boat building, house construction, fish traps and oyster racks. Throughout the region mangrove timber is harvested as firewood or for conversion into charcoal. In Thailand for example, charcoal production is about 263 700 tonnes annually (Aksrnkoae, in Field and Dartnall 1985).

One species which has many uses is the mangrove palm *Nypa fruticans*. The fronds are used for thatching or basket weaving — the thatch is more durable than that of the coconut palm. The fruit may be preserved, eaten raw or cooked as a vegetable.

From the sap, sugar, vinegar and an alcoholic drink (called 'arak' in Indonesia) are distilled. Studies by the Forest Research Institute of the Philippines indicate that with improved technology and better management, alcohol production from *Nypa fruticans* can reach about 18 000 L/ha/year, compared to sugar cane which can produce 3500 L/ha/year (Jara, in Field and Dartnall 1987).

There has already been a discussion of the importance of mangroves to fisheries in Australia. Throughout South-east Asia the fisheries based on mangroves are vital to local economies. In Indonesia, for example, a range of fish, shellfish and crustacea are harvested for home use or local sale.

In Thailand in 1979-80, shrimp/prawn production was 117 300 tonnes, out of total fishing production of 1.73 million tonnes there are in export industries (Aksrnkoae, in Field and Dartnall 1987).

"Florida's wetlands support an US$18 million shrimp fishery."

"...Studies by the Forest Research Institute of the Philippines indicate that with improved technology and better management, alcohol production from *Nypa fruticans* can reach about 18 000 L/ha/year, compared to sugar cane which can produce 3500 L/ha/year..."

"Throughout South East Asia the fisheries based on mangroves are vital to local economies"


Wet Paper

Figure 109.1 Asian fishing industry

Threats to mangroves

"In the Philippines, 195 831 ha of mangroves had been cleared to make way for fish ponds by 1981, representing 48% of all mangroves in the country ."

"Enormous destruction of mangroves and tidal wetlands has occurred as a result of filling to create new land for airports, harbour faculties, industrial development, housing..."

"There is nearly always an increase in sedimentation, which leads to a decrease in water quality and lower dissolved oxygen levels..."

Aquaculture industries are of increasing importance both for local consumption and for export. About 5% of the marine shrimp production in Thailand is from Aquaculture farms within mangrove forests. In the Philippines, 195 831 ha of mangroves had been cleared to make way for fish ponds by 1981, representing 48% of all mangroves in the country (Saenger, in Field and Dartnall 1987).

The major threat to mangroves in Australia is people. The vast majority of the population live in the coastal zone, within an hour's drive of the coast, and going to the beach has become part of the Australian way of life. In the last ninety odd years, pressures of agricultural industrial and even recreational activities have made a major impact on tidal wetlands. Numerous human activities are threats to mangroves, and the combined effects of some of those may well be disastrous to ecosystems.

Reclamation

Enormous destruction of mangroves and tidal wetlands has occurred as a result of filling to create new land for airports, harbour faculties, industrial development, housing, etc. Mostly the fill comes from dredging of nearby tidal or intertidal areas; only occasionally is the fill from terrestrial sources. American experience would suggest that for each hectare of reclaimed land, three hectares of surrounding waters needs to be dredged (Hegerl, in Clough 1982)

Examples of reclamation for dry land use in South-east Queensland are 850 ha of mangrove and 340 ha of wetlands lost to the Brisbane airport development, and 85.5 ha of mangrove and 32.3 ha of wetlands for the Fisherman Island / Brisbane Port complex. Similarly large tracts of mangrove and tidal wetlands have been reclaimed around Gladstone for industrial development. The problem may compound itself in that reclamation for one development may lead to a second and so on.

The effects of reclamation on surrounding areas are threefold — physical, chemical and hydrological.

There is nearly always an increase in sedimentation, which leads to a decrease in water quality and lower dissolved oxygen levels. Where intertidal vegetation is lost, there is a reduction in productivity: food webs change from being detrital-based to plankton-based. Thus there may be alteration to the fauna of the area.

Estuarine landfill modifies tidal range and pattern of tidal inundation. This affects mangrove flora and fauna elsewhere in the estuary.

Murray Waite

Figure 110.1 Reclamation of wetland areas for marina berths

Qld Fisheries

Figure 111.1 Reclamation of wetland areas for agricultural purposes. Extensive dieback is shown in adjacent areas.

Because of changes to current patterns there may be accelerated erosion or sedimentation in other parts of the system; in which case corrective measures may cause even more damage to estuarine organisms.

Where landfill occurs, other problems may also result — storm water runoff may carry silt and pollutants from residential areas, factories and vehicles into streams.

"On the Gold Coast, almost the entire mangrove ecosystem of the Nerang River has been lost ..."

Canal development

'In contrast to America canal developments which have generally been constructed in wide shallow bays, almost all Australian developments are built on floodplains in the lower estuarine reaches of large narrow-mouthed rivers.' (Morton 1989)

"... a similar pattern of destruction seems to be repeating itself in all Australian states."

On the Gold Coast, almost the entire mangrove ecosystem of the Nerang River has been lost. Extensive modification of the Noosa and Mooloolah Rivers has occurred on the Sunshine Coast. There has been some development on most other estuaries from Noosa south into New South Wales.

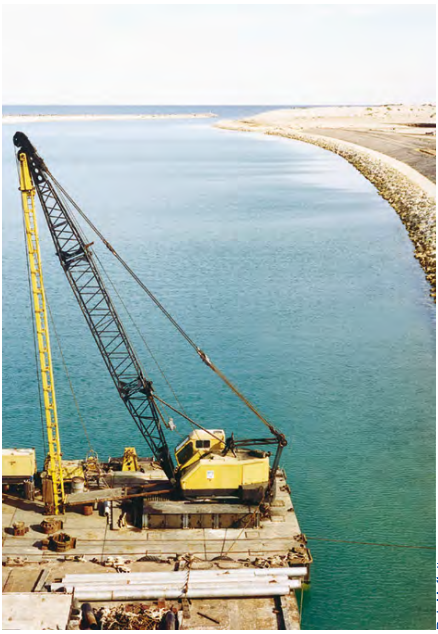
The total loss of mangroves to development either for dry land use or canal estates between Coolangatta and Caloundra from 1974 to 1987 has been put at 1361 ha.

Murray Waite

Figure 112.1 Development on the Gold Coast has removed significant areas of mangrove forest (Photo courtesy Murray Waite and Associates)

This large-scale mangrove reclamation has been offset by a mature regrowth of only 127 ha. In addition 592 ha of saltmarsh - claypan has been lost. There is no evidence of natural recovery. In all, this represents a loss of 9% of mangrove and 11% of salt marsh/claypan between Caloundra and Coolangatta from 1974 to 1987 (Hyland and Butler 1988).

Development of canal estates may even create a problem of biting midges. Flooding and erosion have occurred in southern Queensland canal estates. In canals where water circulation is poor, problems of stagnation recur. Tidal ranges may be modified in estuaries and flood patterns may be altered. Some canals may act as silt traps. Morton (1988) suggests that fauna in canals is similar to its river counterparts, but is substantially less abundant.



Bob Moffatt

Figure 112.2 Canal development in Western Australia

Control of biting insects

The various biting midge species (sandflies) breed in a narrow band around the mean neap high water mark. Each species has restrictive habitat requirements, and only one is dependent on mangroves. Midges rarely travel more than 400 m from their breeding sites (Hegerl, in Clough 1982).

It is rather ironic that real estate developers, in creating sandy beaches in canal estates, have actually created optimum breeding conditions for these insects.

Similarly, mosquitos normally do not breed in mangrove areas which are daily covered by tides. Yet when mangroves are cleared, or when tidal inundation is restricted, optimum breeding conditions are created, especially for the saltmarsh mosquito (*Aedes vigilax*) which is common on all our coastlines except the southern.

Aerial spraying and fogging is used by councils in an effort to control biting insects but apparently has caused fish kills. At present an organophosphate called 'Abate' is being used as a larvacide for biting midge and mosquito control in southern Queensland. This chemical is said to have low toxicity to mammals and appears to be less toxic to marine organisms than other chemicals used (Hegerl, in Clough 1982).

"It is rather ironic that real estate developers, in creating sandy beaches in canal estates, have actually created optimum breeding conditions for these insects."

However, controllers who use 'Abate' appear to have taken no account of the effect on food webs in the ecosystem (for example the long-term effects on whiting population, which in their larval stage feed upon the larvae of biting midges), or the effect upon other insects, which pollinate the various intertidal flora.

These effects are invisible: the mangrove forest looks the same, and people don't worry about what they cannot see.

Bund walls

Bund walls are constructed along the coast by developers or farmers to prevent tidal flooding. The mangroves on this flood land can be cleared, and the land then can be used for other purposes. One such use is to provide effluent ponds for industry. Bund walls are vulnerable to flooding. Effluent may overflow the walls or, even in normal periods, leach through the substrate.

In the Cairns area, more than 720 ha of wetland fronting Trinity Inlet has been bunded to grow sugarcane. A considerable wetland area between Rockhampton and St Lawrence has been bunded to provide grazing land. Both of these areas were formerly rich in barramundi.

There has been little investigation in this country into the relative value of natural production from a given area, compared with the value of production from the same area after reclamation. However in South-east Asia, '... construction of fish ponds in mangrove areas can result in a substantial net loss of fisheries production' (Turner 1977).

Dave Claridge

Figure 113.1 Bund walls such as this close off areas of coastal wetlands, causing major changes in the ecology of the area and long term changes to fish stocks.

Water pollution

'Little is known of the effects of pollution on mangrove ecosystems, but it appears that mangroves themselves are able to survive reasonably high levels' (Hegerl, in Clough 1982). Mention has already been made of the role mangroves can play in the prevention of metal leachates from rubbish tips entering the sea.

"Little is known of the effects of pollution on mangrove ecosystems, but it appears that mangroves themselves are able to survive reasonably high levels."

However Hegerl further noted that in tidal tributaries of the Brisbane River, while mangroves remained healthy amid a variety of pollutants including toxic chemicals, there was almost no invertebrate fauna present.

There have been suggestions that in tropical areas, mangrove forests may well supply a tertiary treatment for sewage Nedwell 1974 — a good reason for protecting wetlands.

Two problems arise: secondary treatment of sewage does not remove toxic waste that can be harmful to marine life, or to human consumers of contaminated seafood; nor does secondary treatment remove viruses which might be harmful to users of the waterway.

It might be that mangroves would survive bad pollution but the rest of the biosystem would either be destroyed or so badly contaminated it could not be used. As Hegerl points out, 'clearly this is one area where detailed environmental studies are needed'.

Algal blooms in the Murray-Darling River system during 1992 clearly illustrate the problems which can arise in inland waterways as a result of the over use of fertilisers, pesticides and so on leaching into waterways. However, little is known of the long-term effects of similar usage leaching into coastal river systems.


Dave Claridge

Figure 114.1 Dredging in the Mary River

Estuarine dredging

Dredging in estuaries may be carried out for a number of different reasons—the maintenance of shipping channels or mining of sand or gravel.

The environmental impact of these activities includes destruction of habitat and benthos in the dredged area, an increase in turbidity and elevation of current flow patterns. In the case of dredging to maintain shipping channels, spoil is often dumped in nearby mangrove or marsh areas.

Sand mining of beaches adjacent to estuaries may also cause problems. For example, Cudgen Creek in NSW 'which was once a productive mangrove estuary supporting fourteen commercial fisherman has been virtually destroyed by dredging spoil' (Hegerl, in Clough 1982).

River impoundments

One of the more insidious threats to mangrove and estuarine ecosystems is the construction of dams, weirs and barrages in the catchment area. In a country like Australia where potable (drinkable) water is at a premium these thing are necessary, if not vital to the survival of the population. However, such activities result in drastic changes to the estuary. These include:

- increased siltation
- increased river bank erosion
- alterations to tidal range
- increased speed of flood run off
- variations in salinity.

As well as affecting mangroves these factors also affect their associated food webs and fish populations.

Management issues

Management of mangrove ecosystems depends on the government view of their value. For example, in much of South-east Asia, management means controlling exploitation for firewood, timber or woodchip production, or clear felling for either agriculture or mariculture (Hegerl, in Clough 1982) Losses of mangroves in South-east Asia measure 91% in Singapore, 45% in Malaysia, 63% in the Philippines, and between 35% and 55% in Thailand (Hyland and Butler 1988).

In these places little notice has been taken of the needs of the local people who use mangrove ecosystems as part of their daily food source. Their value as a resource for the fishing industry does not appear to have been considered to any extent in a number of Asian countries.

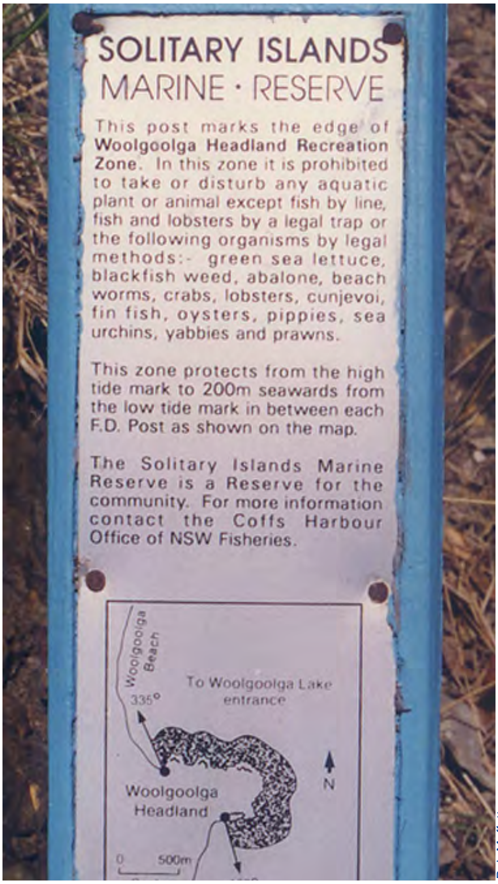
In Australia, some goals for the management of mangroves may include:

1. preservation of the ecosystem audits natural processes. These processes include the preservation of representative as well as rare or endangered species
2. protection of recreational and commercial fishing
3. preservation of areas for scientific and educational study
4. protection against erosion, siltation and flood damage
5. preservation of aesthetic and recreational qualities of natural shorelines (Hegerl, in Clough 1982)

Before any of these or other goals can be achieved there is a need for further research into mangrove ecosystems. The table over indicates the damage already done to the Australian estuaries.

Dave Claridge

Figure 115.1 Barrage - a river impoundment



Bob Moffatt

Figure 115.2 National park and marine reserves are needed to save our mangroves.

Table 116.1 Percent of estuaries dredged

States	% of estuaries with	
	Cleared catchment	Excellent water quality
Qld	45	48.5
NSW	75	0
Vic	75	14.3
SA	0	0
WA	14	83.4
NT	1	97

(from Bucher and Saenger 1991)

"Mangrove destruction does occur naturally and is not always the result of human activities.."

Estuaries which are threatened due to siltation, pollution, or sedimentation in Queensland include Trinity Inlet in Cairns, and the Burdekin, Fitzroy, Brisbane and Mary Rivers. It is no coincidence that there are major population centres with important fisheries and tourist industries which are backed onto by major agricultural development in their catchments.

Research programs ought to focus on pollution effects: sewage, and farm run off, especially in relation to nutrient build up either within mangroves or in offshore systems such as a nearby coral reefs. There is a need to look at the effects on environments of the new ecotourism and the kinds of controls that will allow development but effectively manage the ecosystem so that minimal disturbance occurs. Also, in view of the medicinal usage by indigenous people of the whole mangrove range, there is a need for research into the recovering of drugs for medical use from this source.

Every Australian needs to be more aware of the role and value of mangrove ecosystems. It is only people power that will move politicians to provide and enforce management policies.

There are a number of ways this can be achieved:

1. a public education program
2. use of the media
3. education programs through schools, so that parents learn from their children, and a more environmentally aware generation follows this one.

Dave Claridge

Figure 116.1 Mangrove destruction does occur naturally and is not always the result of human activities. This was once a mature forest of *Avicennia marina* and *Xylocarpus granatum*. The breakdown of protecting dune systems has allowed sand to be pushed into the forest, covering the mud and preventing aeration. Thus the whole forest has died.

Since the early 70's, various groups have called for controls on mangrove destruction in this country - littoral societies, commercial fishing organisations, marine education and naturalist groups. In Queensland at least, the commercial fishermen's lobby has been successful in that some eighty-two areas have been set aside as habitat reserves, wetland reserves or fish sanctuaries. Marine parks have been set up in a couple of places along the Australian coast, but in some cases the protection of the tourist dollar appears more important than management of the ecosystem. Coastal parks and marine reserves in other States offer protection to shorelines.

"Every Australian needs to be more aware of the role and value of mangrove ecosystems."

One problem is that there is little or no account taken of damage which may be done in surrounding areas, and which may impact on such reserves anyway (see Figure 117.1).

In Australia, environmental impact assessment is sometimes required before development can take place. In mangrove or wetland areas, often more than one government department is involved; yet one report often suffices for all even though criteria may be vastly different. Often the environmental impacts on the site and the surrounding area are only cursorily investigated, if at all.

Tim Ryan

Figure 117.1 Mangrove destruction caused by human activities. Here mangroves have been cut down to build a new house on a river bank. Poor knowledge by local management authorities allows this to occur.

"Often the environmental impacts on the site and the surrounding area are only cursorily investigated, if at all."

How often is the vital, comprehensive field work necessary to the integrity of the environmental impact statement (E.I.S.) only half done, if at all? When commercial development is involved, if is usually the developer who commissions, and pays for, the E.I.S., and in most cases they get what they pay for. Politicians may pay lip service to the need for an environmental impact study, but often little or no notice is taken. Indeed, the decision to proceed with development may have already been taken.

Most Australian states actually have very good legislation to protect coastal wetland areas but their legislation appears to be a toothless tiger. Few newspaper articles can be found that describe cases where developers have been prosecuted for wetland destruction.

Regeneration of devastated mangrove areas is a slow process, whether or not the destruction occurred naturally or as a result of human activities.

For example, between Caloundra and Coolangatta in the period from 1974, there was a natural increase of 127 ha (Hyland and Butler 1988). However the process can be speeded up.

Qld Fisheries

Figure 118.1 The result of an ongoing revegetation program at the mouth of Cabbage Tree Creek in Moreton Bay Queensland. This photo was taken in 1987.

The Queensland Department of Primary Industries Fisheries Division undertook a regeneration program at Wallum Creek on Stradbroke Island in an area naturally devastated by prolonged flooding in 1979 (Quinn and Beumer).

More recently an experimental replanting program at the mouth of Cabbage Tree Creek in Moreton Bay has indicated promising results as shown in Figure 114.1 and 119.1 below (Beumer, pers. contact, 1993).

Since 1978 a number of successful regeneration programs have been carried out in NSW by the State Pollution Control Commission in polluted areas along the Parramatta River among using *Avicennia marina* and *Aegiceras corniculatum* (SPCC 1992). Growth rates for *Avicennia* of 5-7 m was recorded over a three year monitoring period in the program area.

The Matang Forest in Malaysia has been managed as a source of charcoal production since the beginning of the century.

A program of clear felling is undertaken by local managers, using a thirty year rotation, and leaving seven seed trees per hectare. If after two years, regeneration is unsatisfactory, the areas are replanted manually using *Rhizophora* sp.

"Many Australian States actually have very good legislation to protect coastal wetland areas but their legislation appears to be a toothless tiger."

Figure 119.1 The same area as the previous page 10 years later

The result of this is a monospecific forest which successfully sustains an industry worth $20 million annually (Ng, in Field and Dartnall 1987).

As a result of these, and other revegetation programs overseas, it appears that revegetation of devastated mangrove areas is a slow process but can be successfully carried out. Given what we now know of the economic importance of these ecosystems, revegetation may well be one way of ensuring mangrove survival, and the survival of dependent industries.

The future

So where do we go? What is the future of mangrove ecosytems? Mangrove communities take up about 22% of the Australian coastline (Clough *et al* 1982), and the vast majority of Australian estuaries contain mangrove communities.

We need:

1. a coordinated approach to research, the results of which should be shared
2. a national media education program on the need for management and protection of estuarine and mangrove wetlands
3. a single authority, appropriately funded and staffed, in each state, which has the necessary power and responsibility to manage and protect estuarine and coastal wetlands.

Bob Moffatt

Figure 120.1 Future canal estate??

Lab exercise 4.1 Water quality and mangroves

What to do

- If you are interested in using chemicals and equipment to test mangrove water quality, the following projects are details are available in Section 2 Maintaining water quality of our Aquaculture flipbook.
    - Making a turbidity tube
    - Testing water for turbidity
    - Making a Secchi Disc
    - Testing water for total dissolved solids
    - Making a salinity hydrometer
    - Testing water for Nitrates
    - Testing water for Nitrites
    - Testing water for Ammonia
    - Testing water for Dissolved oxygen
    - Testing water for pH
    - Making a biofilter
    - Making a sponge filter
    - Making an undergravel filter
    - Making an algal scrubber
    - Making a water sampler
    - Making a syphon

Analysing your results

- Use your results, reference books and the internet to discuss, justify, explain, present or verify your data.

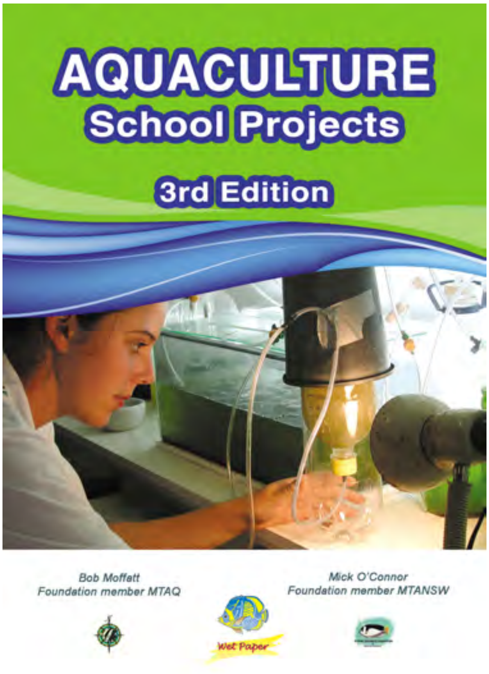


Figure 121.1 Wet Paper's 2014 Aquaculture project flipbook
Wet Paper

Lab exercise 4.2 Growing mangroves

Many mangroves are viviparous (which means the seed germinates while still in the fruit) and will grow rapidly when placed in a suitable environment.

You will need

- potting mix
- sand (beach sand will do)
- pot
- plastic foam
- distilled water
- ice cream container
- viviparous seedlings of *Avicennia*, *Ceriops*, *Bruguiera gymnorrhiza*, *Rhizophora stylosa* or *Aegiceras corniculatum*

What to do

1. Mix the sand and the potting mix in equal amounts and place into the pot. Wet thoroughly with sea water and place the pot into an ice cream container of water.
   The best seedlings to use are those that have been hardened by sea water, so use some that have been washed ashore and not taken directly from a tree.
2. Place the seedling on to the mix (*Avicennia*) or spear into the mix for *Aegiceras, Ceriops, Bruguiera* and *Rhizophora*. The sand mix must be kept damp at all times.
3. Suspension (hydroponic) technique. Place a hole into a piece of foam, and cut out to fit either a beaker or an ice cream container.
   Fill the container with 50% sea water and 50% distilled water. Place a seedling in the hole of the foam and float in the container.

Analysing the results

1. Evaluate the composition of potting mix and the success growth rate.
2. List the variables associated with this experiment and evaluate how well they were controlled. Make suggestions for improvements and if you had a research grant, what would you do with the money.
3. Describe your experiment listing the sources of materials.

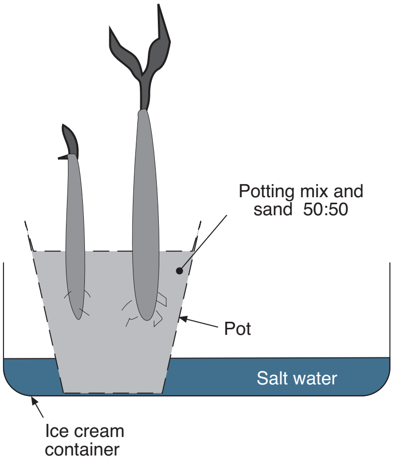


Figure 122.1 Class experiment
Bob Moffatt

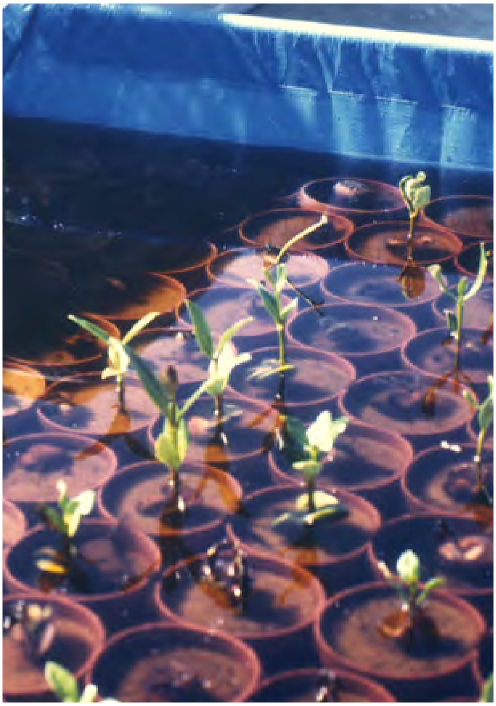


Figure 122.2 Outgrowing tub
Jacobs Well EEC

Lab exercise 4.3 Make your own insect repellent

by Jacobs Well EEC

What to do

- Investigate the use of natural oils in combination with baby oil, methylated spirits and Dettol as insect repellent.
- Mix up the following and test it out
  - 1 x bottle of methylated spirits (1 litre)
  - 1/3 x bottle of citronella (25 mL)
  - 1/2 x bottle of baby oil (250 mL)
  - 1/2 x bottle of Dettol (500 mL)

  Mix all ingredients together in a 2L cordial (or similar) bottle and place in spray bottle as required.

Insect repellent investigation

- Bring to class as many different brands and types of insect repellent as possible.

  You are not, for safety reasons, to spray any aerosols inside and certainly not at each other.
- Divide them into small groups (three in a group will be sufficient), and investigate the small print on the can or pack. Be aware of such things as: danger, aerosol, excessive use, inflammable, etc.
- Record your data in a table or as anecdotal remarks.

Analysing your results

- Evaluate the results making recommendations based on percentage success. For example, of the 3 bottles of home made disinfectant, sample A proved most successful for 70% of participants.
- Draw graphs to support your results.
- Evaluate the effectiveness of the more expensive brands of insect repellent.
- Discuss the importance of wearing insect repellent as a health issue in Northern Australia.

Optional EMI

Introduced mosquito species pose a huge threat to the health of Australians in Northern Australia. Biosecurity measures are in place to protect us, however mangroves provide the ideal breeding ground for introduced species.

Evaluate or explain the statement that:

> *"Introduced and migrating species have the potential to alter marine environments and adaptations of native species."*

Compare this to the statement that

> *"Education of stakeholders is essential to encouraging sustainable management practices".*

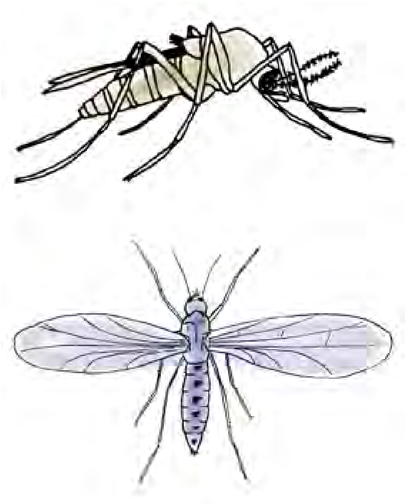


Figure 123.1 Adult midges
John Burnett

Warning

Some people are allergic to certain home remedies and students with allergies or skin disorders should not participate in this activity.
If students or their supervisors are in doubt, they should consult their doctor.
Alternatively consult the book the Green Cleaner, by the Australian Conservation Foundation c/- 340 Gore St, Fitzroy, Victoria, 3065.
Let us know the results.
We're always after new brews!
Jacobs Well Environmental Education Centre
MS 1372
Beenleigh 4207

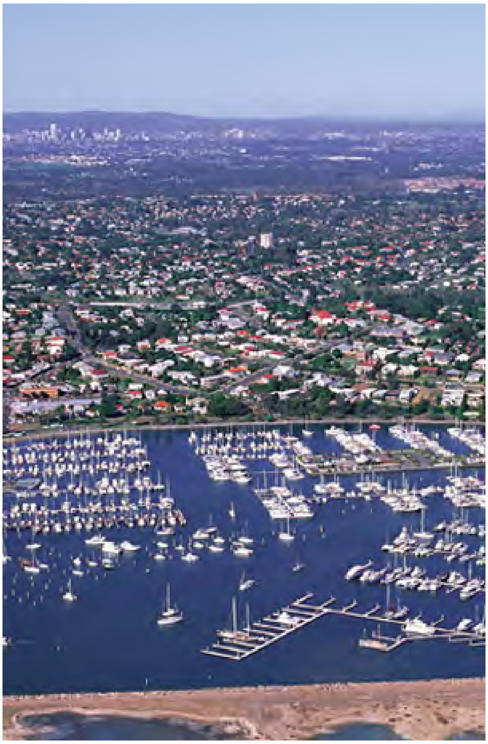


Figure 124.1 Finished marina
Murry Waite

Figure 124.2 Yacht in slip yard
Bob Moffatt

Project 4.1 Marina development

What to do

Visit a local marina to ascertain if:

1. the facilities offered by the marina meet the needs of the public being catered for.
2. any initial effects on the environment when the marina was constructed.
3. any ongoing effects on the environment that the boats and associated activities may have.
4. any ways in which the running of the marina could be changed to minimise its effects on the environment.

Notes

1. The history of the marina may have to be researched to ascertain the effects of construction. Contact the local council, or previous owners to find out the origin of site—was it a mangrove habitat, or had there already been some kind of prior development?
2. Guest speakers/guides are important to this exercise. A marina employee may be able to show you around the marina and explain facilities and services offered.
3. Find out what types of processes were employed in construction and if the area was dredged.

   Make observations on possible effects on the natural habitat surrounding the marina.
4. Draw a plan like the one shown on the next page.

Analysing your results

1. Describe the boat storage facilities available at the marina (draw a plan like the one shown on the next page).
2. Identify what services are provided to moored boats.
3. Account for other facilities are available at the marina.
4. Evaluate the initial impact the marina would have had on the environment when it was constructed.
5. Determine ongoing effects would the presence of the boats have on the environment.
6. Describe the procedure for defouling a boat hull.
7. Suggest improvements that could be made by the marina management to decrease the effects that boats and their associated activities have on the surrounding environment.

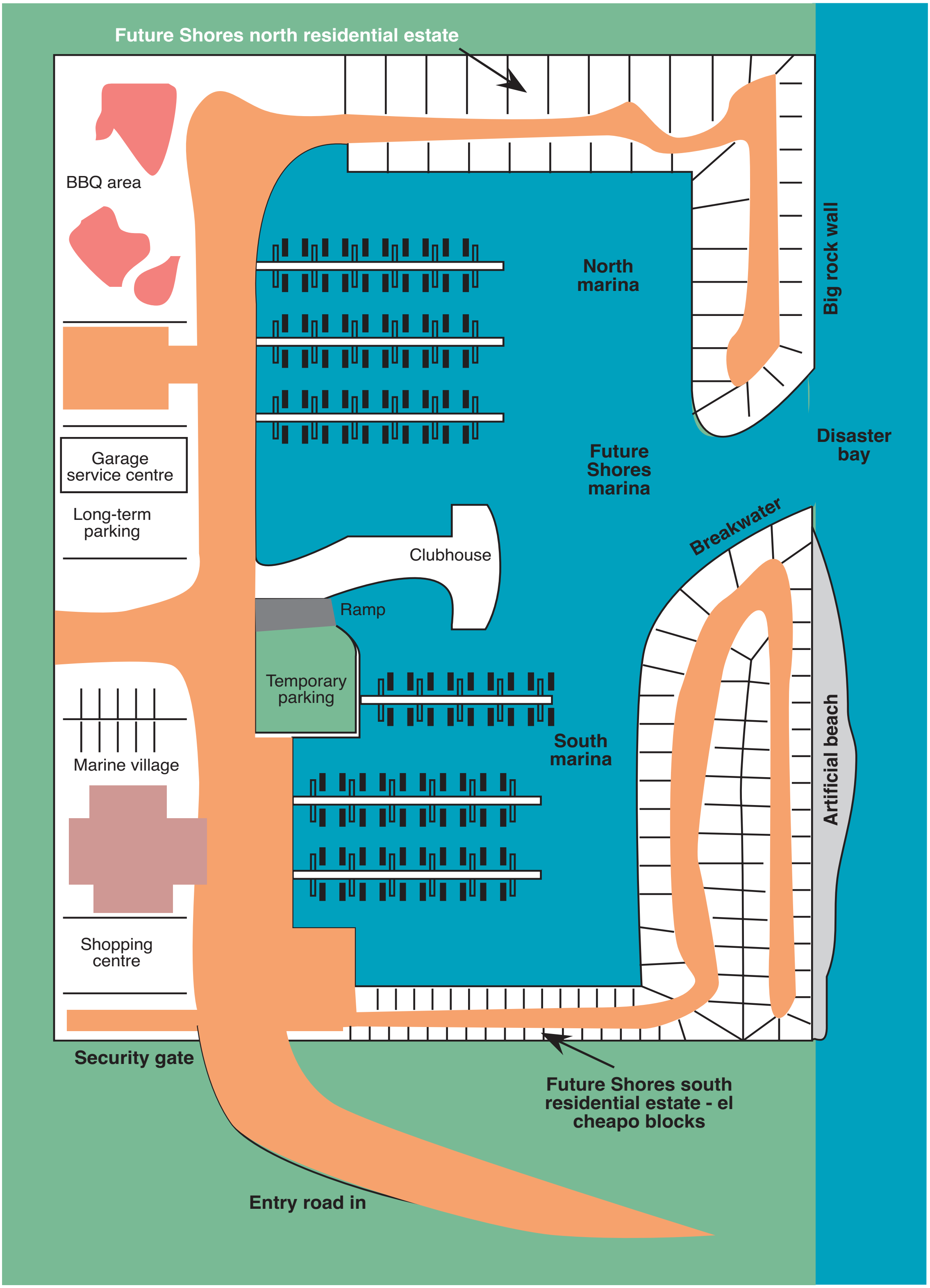


Figure 125.1 Sample marina plan
Bob Moffatt

Figure 126.1 Dredge in new Gold Coast canal estate
Bob Moffatt

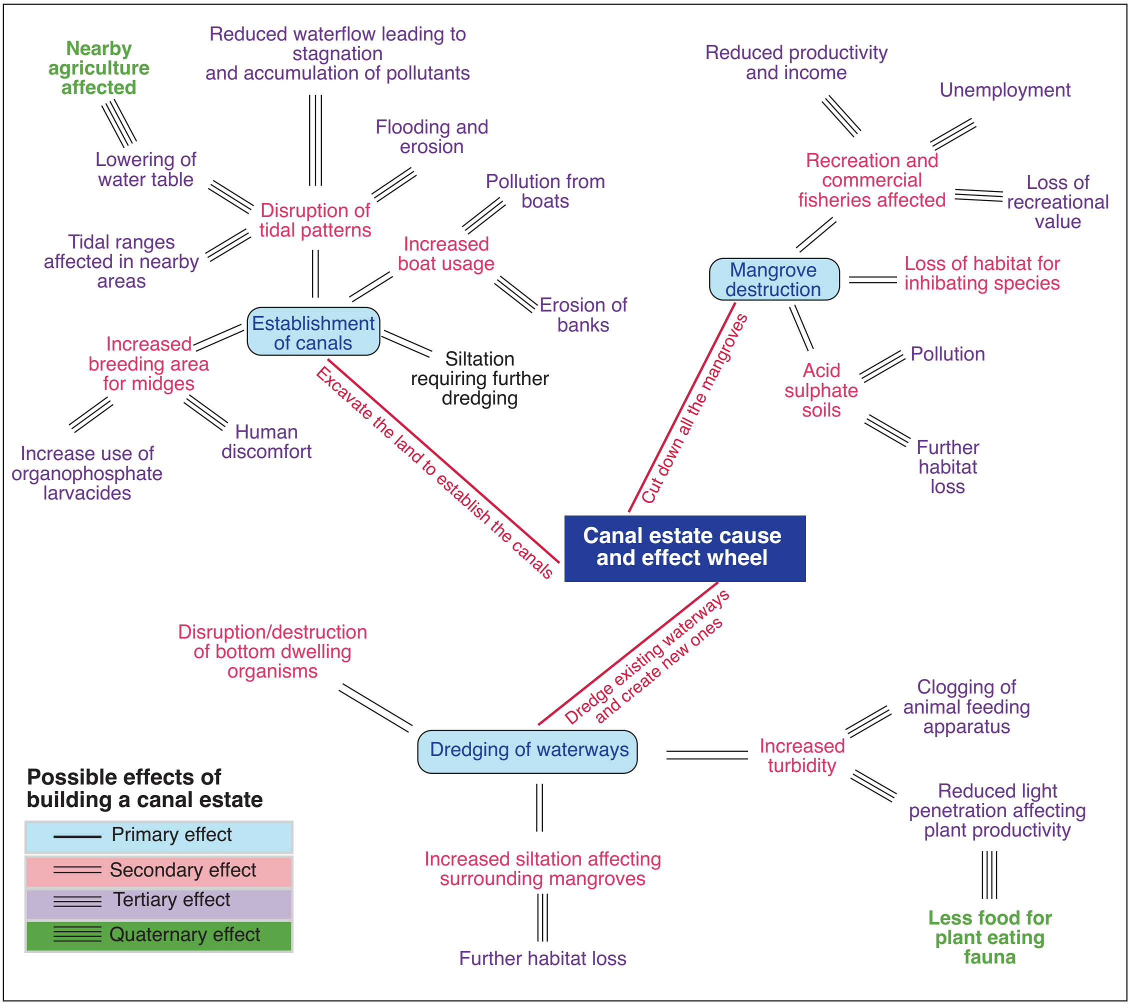
Project 4.2 Effects of canals

What to do

Research and visit a local canal estate to observe its development and ascertain the effects on the local environment. A variety of formats could be used. The cause and effect wheel, illustrated below, is one possible format which would show how the development could have a number of associated effects. Research is important to find out the prior nature of the site and the methods used in the development. Guest speakers, eg. local council members, local fishers etc. are of great value in investigations such as this one.

Analysing your results

1. Summarise your findings in the table on the next page.
2. Evaluate the cause and effect diagram from Figure 126.2 in a 250 word essay using a local canal as an example.



Based on an original idea from, 'Teaching for Ecological Sustainable Development: Guidelines for Years 11 and 12 Geography, Department of Education, Queensland 1992'.

Figure 126.2 Cause and effect diagram

Development /Consequence table

Type of development : Canal estate		How likely is this consequence of the development? Answer yes or no.				Your evaluation of the consequence. Answer yes or no.				
Developments that might occur	Possible consequences	Certain	Probable	Possible	Almost impossible	Very favourable	Favour-able	Little or no impact	Unfavour-able	Very unfavour-able
1. Establishment of canals	a. Erosion of banks b. Disruption of tidal patterns									
2. Mangrove destruction										
3. Dredging of waterways										

Source — Modified from P-12 Environmental education curriculum guide (Dept of Education Qld). After an idea from Futures Unlimited, by R.M. Fitch and C.M.Suengalis (National Council for the Social Studies, Washington, D.C. 1979)

Figure 127.1 Development consequences table

Bob Moffatt

Project 4.3 Organise a conservation role play

You will need

Role play cards (See over page)

What to do

The roll play

1. Each player or group of players, takes on the role of a particular interest group that will be involved in deciding the future of a given area of mangroves/foreshore in a local area. One group takes on the role of the local council which must decide the future of the mangrove area.
2. Each group follows the objectives outlined on their role card and bases their arguments around these points. These views are expressed firstly at a public meeting and then later in a spirit of compromise during the lobbying and decision-making process.
3. Finally the council brings down its decision—hopefully along the lines of protecting the mangroves for those interested groups. However the council should also make provisions for other groups to use nearby areas which are not as susceptible to environmental damage.

Examples of possible council decisions.

- Area of mangroves protected because of arguments put forward by local birdwatchers, local fishers/crabbers, offshore fisher.
- An old dump/tip - no longer in use - made available for trail bikers club.
- A cane farm - no longer needed to meet the local mill's requirements —made available for football club.
- Heavily logged forest made available for skirmish war games club on the provision that they undertake a replanting scheme of native plants to return forest to original condition.
- Paradise Cove developers passed on to a neighbouring council which has an area of land needed for development.

From this activity students should recognise that different people have different needs but that their needs can be met in a spirit of compromise with everybody 'winning' and at minimal cost to the environment.

Kerry Kitzelman

Analysing your results

1. Evaluate the success of the game by a set of predetermiend criteria.
2. Compare the different attitudes of stakeholder groups in a table.
3. Discuss the statement that "Consultation through stakeholder groups guides policies relating to sustainable management practices"

Local birdwatchers group

We want:

1. Mangrove area to be preserved so that birds will have a place to feed and live
2. Banning of all fishing and other activities (apart from birdwatching) in the area so birds are not scared away
3. The erection of 'hides' from which to observe and film birds.

Kerry Kitzelman

Trail-bikers club

We want:

1. Part of the mangrove area rezoned for use by the club and other bike groups
2. Provision of water jumps and mud areas for scrambling
3. Whole area to be maintained by local council
4. Clubrooms on site.

Local football club

We want:

1. Mangrove area to be filled (possibly using area as a dump) and then levelled and turfed as a new playing site
2. Light towers for night football
3. A grandstand with clubrooms
4. Carparking facilities.

Local council

We want:

1. To reach a planning solution to cater for a majority of the rate payers
2. To study the local area to find sites (e.g. old farm areas no longer used) which could be put to use in the community
3. To decide on a solution which is best for the long-term welfare of the community.

Local fishers/crabbers

We want:

1. Mangrove area to be left untouched so local fish and crabs will have a place to live
2. Size limits and bag limits on fish and crabs to preserve numbers for the future.

Skirmish war games club

We want:

1. Setting aside of mangrove area for the playing of the game Skirmish; fencing of this area with barbed wire.
2. Digging of trenches and bunkers.
3. Building of barracks for members to stay in.

Kerry Kitzelman

Offshore fishers (trawlers)

We want:

1. Preservation of mangroves so young fish and prawns will have a nursery in which to live and grow. Adult prawns and fish will still be able to be caught offshore
2. Preservation of mangroves as the vital producers in the food chains upon which catches depend.

Paradise Cove developers

We want:

1. Mangroves destroyed to enable filling and levelling of site
2. Construction of four multistorey high-rise (ten floors max.) buildings, including one hotel.
3. Tennis courts and nine-hole golf course.

Kerry Kitzelman

This is a long term study and may need to be modified to suit local conditions and your OWN experimental design.

So don't be afraid top take the idea, run with it and change the project to suit.

Project 4.4 Maine paints and marine organisms

Based on an original ideas by Miriam Beiers of Craigslea High School and Bill Fowels, Former Science Head of Department Deception Bay SHS.

Aims

1. To look at primary and secondary fouling organisms and investigate paint additives and their effect on fouling organisms.
2. To invent and test environmentally friendly paint/s that help prevent barnacle and other marine growth on boat hulls. Also to try and invent paint/s that are more effective than current antifouling paints.

Equipment and materials

- fishing line and wooded stake
- petri dishes
- weights
- 10 cm x 10 cm perspex
- oil paint
- range of metal salt additives: copper nitrate, silver nitrate, iron nitrate, etc.

Method

1. Set up a series of control petri dishes in a boat harbour as shown in Figure 130.1.
2. Inspect the petri dishes every day and note the types of organisms that have settled on them.
3. Make a series of paints that contain a number of metal and naturally occurring derivatives. Do this by mixing a known percentage of anti-fouling chemical in a water-based paint.
4. Set up a series of experimental petri dishes below low tide as in Figure 130.2 by nailing to a pole in the boat harbour beside the control petri dishes
5. Compare the results with the control set of petri dishes over time.

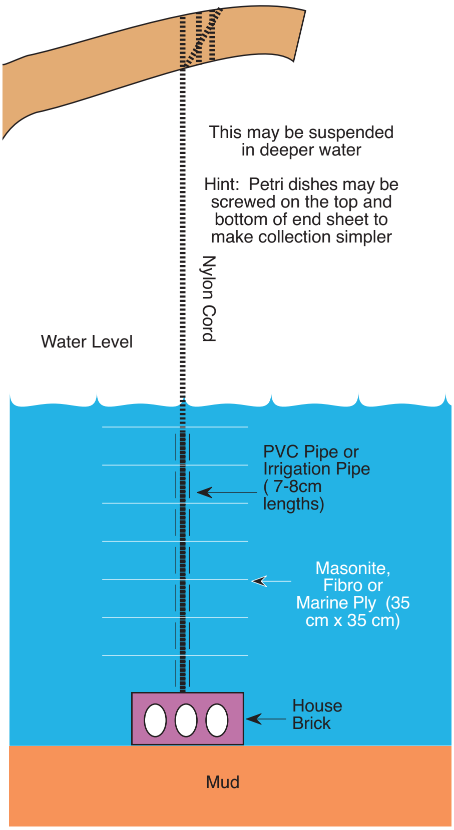


Figure 130.1 Experimental set up
Bob Moffatt

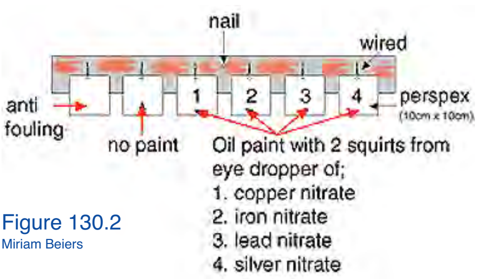


Figure 130.2
Miriam Beiers

Suggestion to analysing your results

1. Compare your results in a data table.
2. Discuss the statement that

   "Longitudinal studies are used to collect data relating to water quality and population density and distribution."

What are fouling organisms?

They are organisms which attach to structures built in the marine environment onto which they permanently attach (for example, barnacles, algae, sea weeds, bacteria, fungi, ascidians (i.e. cunjevoi), sponges, bryozoans, tube worms, molluscs and arthropods).

Another example, the terrido worm (see Figure 131.1) can bore holes to hide, uses its tail to feed, follows along the grain of wood and can bore into concrete and steel.

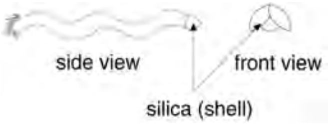


Figure 131.The terrido worm
Wet Paper

Other fouling organisms are the non-destructive animals that slow down boats and ships. Super tankers fouled with these organisms will travel slower and slower. This causes the running costs to escalate because delivery times and dry dock times are extended. In some operations, annual running costs can be more than $2,000,000 per ship.

Methods of control

Some methods of control have included coating the ship's hull with a copper sheath and painting the hull with anti-fouling chemicals (such as copper and tin). However, this often flecks off, becomes porous or slowly leaks poison into the sea. Other methods have included electric protection and sound.

Stages of fouling

The fouling process happens in two stages: primary fouling and secondary fouling.

Primary fouling organisms are usually bacteria/fungi/algae and protozoans. Silt also begins to settle in this phase. These organisms have a direct, little-understood impact on the future settlement of secondary fouling organisms. However, if the primary fouling organisms can be controlled then the secondary fouling organisms will also be controlled. Secondary fouling organisms are larger organisms, for example, barnacles, oysters, weeds, worms, etc.

The usual order of settlement is from plants to animals and happens as follows:

- Days 1 to 3 — bacteria/detritus
- Days 4 to 5 — diatoms
- Day 7 — protozoans
- Days 8 to 14 —hydrozoans
- After 2 weeks — barnacles, oysters, serpulid polychaete (calcarious tubes)

  The type and number of the dominant organism changes depending on the time of the year and or location.

Background information

If marine scientists can invent naturally occurring chemicals, such as tea-tree oil, that can be combined with paint to deter or prevent marine animals such as barnacles from attaching to the hulls of ships then the seas will become cleaner.

Read the background information and experimental design notes before you begin.

In this experiment interesting effects to look for include

- **Edge effects** where there is a different settlement on the edge of a structure compared to the middle.
- **Competition** where the organisms will battle each other for the limited space in a variety of ways. Some types of competition include:
  - Direct aggression (i.e. eating others)
  - Structures that prevent overgrowth (i.e. spikes)
  - Escape by size (i.e. they growth large rapidly)
  - Chemical inhibition (i.e. they produce chemicals)
  - Ability to overgrow

Figure 131.1 Fouling organisms on prop
Bob Moffatt

Figure 132.1 Conduct a poll
Kerry Kitzelman

"Decision making involves the consideration of a range of stakeholders views and a range of alternative pathways for action."

Project 4.5 Attitudes and feelings poll

Take this poll before and after the unit of work. Students will become aware of how their attitudes and feelings about the topic will change or become strengthened after they have more information.

Discuss the subject especially with others who may not share your opinions. In this poll, based on the table opposite, you only have to put a tick in one of the columns for each question. It would be ideal if you were to transfer the results of each poll onto a large sheet of paper for display, it maybe shown as a bar graph.

This is not one where you are "right" or "wrong". It is simply for you and your class to understand what you know and feel about mangroves and other things which you will be looking at and discussing during the next few days.

Analysing your results

1. Compare your results in a data table (Figure 132.1)
2. Discuss the statement that

   "Decision making involves the consideration of a range of stakeholders views and a range of alternative pathways for action."

Figure 132.1 Attitudes and feelings poll

Question*	**Yes**	**No**	**Undecided**
1. All mangrove trees are the same	[ ]	[ ]	[ ]
2. All mangrove areas are smelly	[ ]	[ ]	[ ]
3. Artificial waterways (canals) are the same as natural ones	[ ]	[ ]	[ ]
4. Tidal wetlands are important to bird and fish life	[ ]	[ ]	[ ]
5. Mangrove roots collect sediment and stabilize waterway banks	[ ]	[ ]	[ ]
6. Wetland areas are very rich in nutrients	[ ]	[ ]	[ ]
7. There are laws to prevent mangrove clearing	[ ]	[ ]	[ ]
8. Mangroves have to be cleared before you can build canal estates	[ ]	[ ]	[ ]
9. Mosquitoes and sandflies only breed in tidal mangrove areas	[ ]	[ ]	[ ]
10. We should be more concerned about wetland areas	[ ]	[ ]	[ ]
Total	[ ]	[ ]	[ ]

* After you have completed the questions and collated the information it may be interesting to discuss with the class how much contact you have had with the mangroves and what form that contact has taken.

Appendix 1 Species descriptions


See first edition

Figure 134.1 *Acanthus ilicifolius*


See first edition

Figure 134.2*Aegialitis annulata*


See first edition

Figure 134.3 *Aegiceras corniculatum*

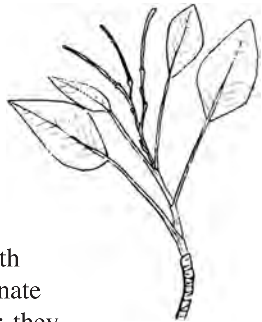
Acanthus ilicifolius

Family: Acanthaceae
Common name: Holly leaf mangrove

A small shrub, which may reach 1 or 2 m in height, normally found only in the littoral zone. The leaves are opposite, glossy, stiff and normally have spiked edges very similar to the traditional Christmas holly, hence its name. It may have a number of stilt roots, and produce attractive pale blue flowers. The fruit is a shiny brown capsule about 30 mm x 10 mm which may contain several seeds.

Flowers: August
Fruiting: Dec - Jan
Distribution: The Northern Territory and Queensland coastline.
Uses: It is suitable for planting in saline areas as an ornamental shrub, where it flowers from about 0.5 m in height. Leaves from *Acanthus ilicifolius* have been used as poultices for pain relief by traditional peoples of Indonesia

Aegialitis annulata



Family: Plumbaginaceae
Common name: Club mangrove

A bushy brown-stemmed shrub which at the southern limit of its range in the Queensland Sandy Straits region, rarely reaches 0.5 m, but may reach 2 m in north Queensland. The leaves are ovate alternate and often with red/brown pits in them; they may have a leathery appearance. Salt is excreted through glands on the upper leaf surface. The trunk is broad at the base, tapering quickly and creating the appearance of a club. They grow mostly on rocky and heavy clay sites. It produces small flowers and is viviparous.

Flowers: Sept - Nov
Fruits: End of summer.
Distribution: Across northern Australia from Carnarvan in W.A. and down the Queensland coast to Fraser Island

Aegiceras corniculatum

Family: Myrsinaceae
Common name: River mangrove

A shrub usually up to 2 m or less, sometimes may become a slender tree up to 4 or 5 m. It is found along the landward fringes of mangrove forests and often forms dense thickets along tidal creeks and rivers as far up as the limit of tidal regions, hence its name. *Aegiceras* has one of the widest ranges of salt and environmental tolerances - it occurs in hypersaline areas on the edges of claypans adjacent to *Ceriops tagal*, yet can withstand up to nine months inundation by fresh water.

The glossy green leaves are alternate and have a film of salt on them, except after rain. Often there is a film of dark mould on the leaf surface; the fungus lives on the secretions from the surface of the leaves but it is not a parasite. It produces thick clumps of white flowers which smell like rotten bananas. Fruits are horn-shaped about 30 mm, and viviparous

Flowers: Late winter/ spring
Fruits: Early summer
Distribution: From around Exmouth Gulf in W.A. across northern Australia and down the eastern coast as far south as Jervis Bay in NSW
Uses: A source of pollen for beekeepers

Avicennia marina

Family: Verbenacea
Common name: Grey mangrove or white mangrove

This is the most widespread mangrove in coastal Australia, being found in St Vincents and Spencer Gulfs in South Australia and as far south as Corner Inlet in Victoria — it is the only mangrove able to withstand the cooler temperatures.

It also is found in varied environments, from the upper reaches of tidal influence in rivers and creeks, where it is associated with *Aegiceras corniculatum*, to newly emerging mud banks which it pioneers along with *Rhizophora stylosa* or *Sonneratia alba*. It is also found in claypan hypersaline areas with *Ceriops tagal*.

Depending upon where it is growing, *Avicennia marina* may be a shrub less than 0.5 m tall to a large spreading tree up to 25 m. Leaf shape varies depending upon the environment. Leaves are opposite. Upper surfaces are glossy green, with a pale grey below. Salt secreting glands are mostly on the underside.

Easily the most distinguishable characteristic of this species is the upright slender peg roots, called pneumatophores, which protrude through the mud from the lateral roots beneath the mud. These play a major role in aeration of the plant.

The orange-yellow flowers are small and appear in clusters in the leaf axils. Fruit are roughly shaped like a flattened egg about 3cm x 2cm; they are viviparous. A second species, *A. eucalypifolia*, occurs in northern Australia.

Flowers: Spring
Fruits: Late summer/ autumn
Distribution: The most widespread species in Australia occurring in all states except Tasmania
Uses: A source of pollen for beekeepers, timber is light and strong and is used for boat building

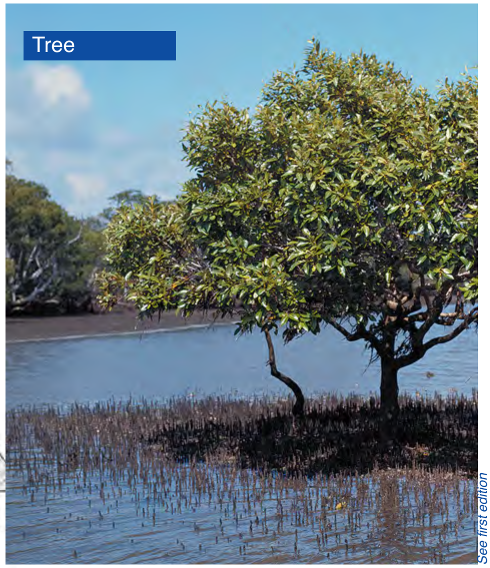


Figure 135.1 *Avicennia marina*

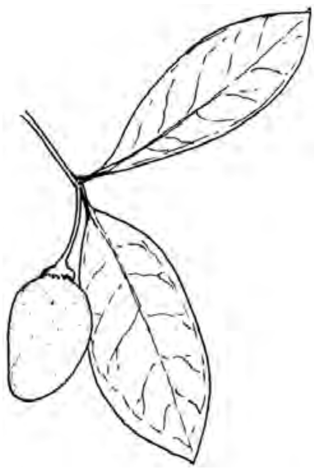


Figure 135.2 *Avicennia marina* leaves and fruit

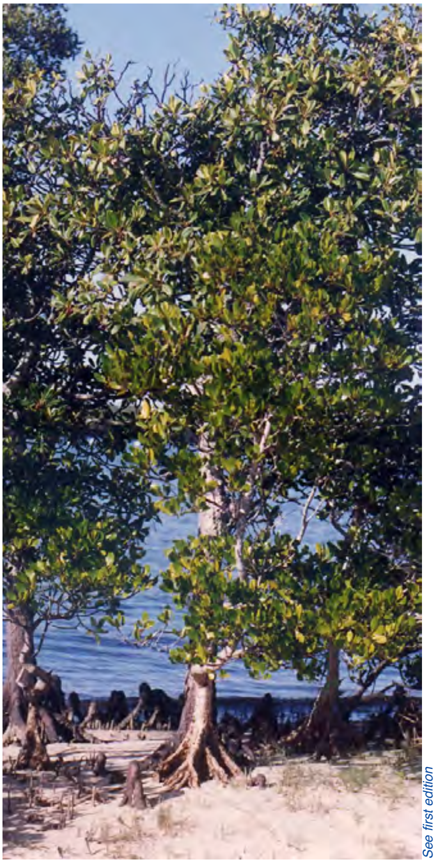


Figure 136.1 *Bruguiera gymnorrhiza*

Figure 136.2 *Bruguiera gymnorrhiza* flower and leaf

Bruguiera gymnorrhiza

Family: Rhizophoracae
Common name: Orange mangrove or large leaf mangrove

This is a large tree which may attain a height of 10 to 18 m, with a dense leafy crown. It tends to prefer muddy/sandy areas which are covered only by spring tides. Buttresses may be present at the base of the trunk in mature trees.

The very large leaves are arranged in opposite pairs. The leaves are glossy green above and paler on the under surface. Single orange flowers are formed at the base of these leaves.

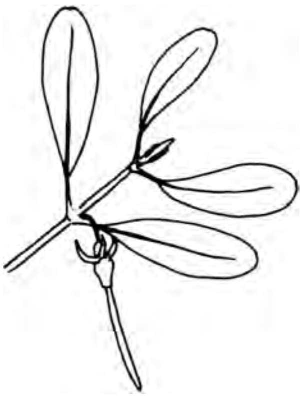
The cigar shaped fruit are viviparous. Apart from the leaf size the other distinguishing characteristic of *Bruguiera* is the knobbly 'knee root' similar to the pneumatophore of the grey mangrove.

There are four other species of *Bruguiera* found in northern Australia, all of which are smaller than *B. gymnorrhiza*. These are *B. exaristata, B. parviflora, B. sexangulata* and *B. cylindrica*. The differences are in the flowers and fruit.

Flowers: Spring
Fruits: Summer (Dec - Feb)
Distribution: Across northern and eastern Australia from NT to Richmond and Clarence rivers in NSW
Uses: Bark for tanning, the timber is very hard

Ceriops tagal

Family: Rhizophoraceae
Common name: Yellow mangrove, spurred mangrove



The genus *Ceriops* appears to be intolerant of lengthy fresh water flooding, but on the clayey soils which form extensive flats near the upper limits of mangrove shores, *Ceriops tagal* var *australis* is one of the most common species.

It occurs as a small shrub or a small tree from 5 to 10 m in height. From the air monospecific stands are clearly defined by the dense yellowish canopy.

Leaves are opposite, obovate in shapes with a notched tip and distinctly yellow-green in colour. The small white flowers appear in pairs at the base of the leaves. Fruit are viviparous. *Ceriops* is characterised by buttress roots.

The bark is pale and both the trunk and the buttresses are roughened by corky lenticels which are important for aeration of the plant.

Two varieties of *Ceriops tagal* occur. The most common and widespread is *C. tagal* var *australis*, and *C. tagal* var *tagal* is found north of Bustards Head (Wells in Clough 1982). A second *Ceriops* species, *C. decandra*, is found in NT and northern Queensland.

Flowers: Late spring, early summer
Fruits: Mid to late summer
Distribution: *Ceriops tagal* var *australis* is common on the whole Queensland coast. It does not occur south of Moreton Bay
Uses: The leaves and bark are rich in tannin (Cribb and Cribb 1985) and are used as a tanning agent overseas. Dried buttress roots are often used as ornaments. Timber is hard and tough and has been used in boat building

Figure 137.1 *Ceriops tagal*

Cynometra iripa

Family: Caesalpincaceae
Common name: Wrinkle pod mangrove

This is another small straggly tree which rarely grows more than 3 to 5 m high. It is found at the upper limit of mangroves, on the edge of the littoral zone. Leaves are pinnate, and on short stalks — distinctive in that the upper pair are always larger than the lower pairs. Leaves are notched at the apex. The fruit are small pods, very deeply wrinkled, ending in a beak-like point. Each pod contains only a single seed.

Flowers: Spring
Fruits: Midsummer Dec - Jan
Distribution: It occurs on the Arnhem Land coast of NT and down the eastern coast from Cape York to about the Mackay /Sarina area
Uses: A purple dye can be made from woodchips of this tree. The timber is light and strong. According to Cribb and Cribb (1985) a lotion prepared from the leaves and oil extracted from the seeds have been used in India to treat leprosy and scabies

Figure 137.2 *Cynometra iripa*

Camptostemon schultzii

Family name: Bombacaceae
Common name: Kapok mangrove

A dense shrub or tree, the Kapok mangrove is regularly seen at 10 to 12 m, but occasionally reaches up to 22 m in height. Bark is grey, and there are distinctive lon longitudinal fissures. Leaves a grey-green; the under surface is g woolly and dotted with red-brown glandular scales. Fruit is a capsule which contains two woolly seeds.

Figure 137.3 *Camptostemon schultzii*

Figure 138.1 *Camptostemon schultzii* leaves

Figure 138.2 *Excoecaria agallocha* leaves

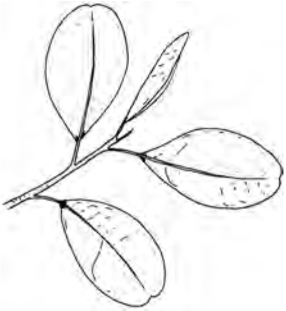
Camptostemon schultzii prefers soft muddy soils which are regularly covered by the tide. It occurs in conjunction with *Avicennia marina* and *Aegiceras corniculatum*.

Flowers: September
Distribution: From the Kimberley Coast of WA and the Arnhem land coast of NT to Cape York in Queensland
Uses: The timber is light and buoyant. Aborigines of the Kimberley coast used it for canoes. It has been used to cure skin disorders, including leprosy (Wightman 1989)

Excoecaria agallocha

Family: Euphorbiaceae
Common name: Milky mangrove

This is a tree or shrub in tropical regions which may reach up to 12 m (Jones 1971), but is usually found no more than 6 or 7 m high.



In temperate areas it rarely reaches more than 4 m.

The bark is grey, smooth, and has long longitudinal patterns of corky pustules. Leaves are alternate.

It grows at the landward edge of the littoral margins, preferring sandy areas, with freshwater input for much of the time.

On Woody Island in Hervey Bay Queensland, it is found on the dune tops on the seaward side at the top of the highest spring tide mark.

Excoecaria is distinguished by its milky white sap or latex, similar to that of the oleanders, which may cause blindness if splashed in the eye. Fruit is a small capsule with three lobes.

Flowers: Late summer Dec - Feb. A second species *E. ovalis* is found in NT It is very similar to *E. agallocha*, except that the leaves are smaller, with a smoother edge

Fruits: Autumn (April - June)

Distribution: From the Kimberley coast of WA, throughout the Northern Territory coastlines to the eastern coast from Cape York and south to the Clarence River in NSW

Uses: Many Aboriginal groups considered *Excoecaria* to be toxic because of the latex and some groups used it to stupefy fish. The flowers are a source of nectar for bees. The latex had a wide variety of medicinal uses, including treatment for leprosy and marine stings. The bark was used to treat body pain and general illness. Malaysians used the roots to treat toothache (Wightman 1989)

See first edition

Figure 139.1 *Excoecaria agallocha*

Heritiera littoralis

Family: Sterculiaceae
Common name: Looking glass mangrove

This is a tall tree, growing up to 15 or 16 m in height. It usually occurs towards the landward edge of the mangrove area, or along the tidal creek edges.

The leaves are large, elliptical, dark on the top, but silvery white underneath. This is due to the presence of small mostly silver scales, but a few occur with reddish centres or brown. These scales give the leaves a silver sheen, and it is this which gives the plant its common name. On mature trees the leaves vary in length from around 120 to 200 mm, but on immature specimens leaves tend to be much larger, more than 300 mm.

Heritiera also develops very large, broad plank-like buttresses, similar to the buttress roots of a number of rainforest trees to which it is related.

The orange flowers are small, and form in loose sprays. Fruit forms in clusters of up to 5 from each flower; each fruit being around 6 - 8 cm long and having a distinctive winged keel.

Flowers: Spring (Aug - Sept)
Fruits: Late Summer - Autumn (Mar - May)
Distribution: *Heritiera* does not appear to occur in WA or NT. Along the Queensland coast from Cape York to about St. Lawrence

See first edition

Figure 140.1 *Heritiera littoralis*

See first edition

Figure 140.2 *Heritiera littoralis* (leaf— left, fruit— right)

See first edition

Figure 141.1 *Heritiera littoralis*

See first edition

Figure 142.1 *Hibiscus tiliaceus flower* and fruit

Hibiscus tiliaceus

Family: Malvaceae
Common name: Cotton tree, swamp hibiscus

This is a small spreading tree, occasionally reaching 7 or 8 m. The underside of the heart-shaped leaves are covered with fine hairs, which give a greyish appearance.

Flowers are yellow with a purple centre and in shape are typical of most of the species. The flowers do not last more than a day, and most mornings are found on ground below, freely open, and having changed colour to a dullish pink.

Hibiscus tiliaceus is regularly seen above the high tide mark on sandy beaches. It also grows below high tide, and is regularly associated with *Avicennia marina*. It is one of the few members of the hibiscus family which is native to Australia.

Flowers: All year in the tropics, spring and early summer in more temperate regions
Fruits: All year in the tropics, late summer in more temperate regions
Distribution: Widespread across the Northern Territory and down the Queensland coast into Northern NSW
Uses: The bark produces a fibre which has been used by Aborigines for cord, fishing lines and nets. Buds and shoots are edible after cooking. Medicinal uses have also been reported (Cribb and Cribb 1985)

See first edition

Figure 142.2 *Lumnitzera racemosa* flower and fruit

Lumnitzera racemosa

Family: Combretaceae
Common name: Black mangrove

In tropical regions, this is a small tree reaching 6 or 7 m in height, but towards the southern limit of its range it becomes a small shrub rarely reaching more than a metre. Bark is very dark grey to black—hence the common name—and longitudinally fissured.

Leaves are alternate, variable in size, narrowly obovate, and with a gland at the end of the mid rib. Flowers are white.

Lumnitzera sp. are found in muddy substrates near the landward edge of the littoral zone, and commonly associate with *Ceriops, Aegialitis* and *Avicennia*.

A second species, *L. littorea,* occurs in north Queensland and Northern Territory. It is very similar to *L. racemosa* except that it produces red flowers and has small knee roots.

Flowers: Spring and early summer
Fruits: Autumn
Distribution: *Lumnitzera racemosa* occurs widely on the Kimberley coast of WA in the NT and down the Queensland coast from Cape York to Moreton Bay

Nypa fruticans

Family: Arecaceae
Common name: Nypa palms, mangrove palm

This is the only palm among the various mangrove species, and as such is closely related to lawyer cane and coconut palm. The stem is very short and thick; fronds may be up to 9 m long, and usually only seven or so to each stem. The single fruit head, which may weigh up to 20 kg, is composed of many fibrous, pear-shaped fruits, each enclosing a single small nut (Saenger in Clough 1982) suggests that *N. fruticans* is viviparous.

N. fruticans forms monospecific stands bordering quiet back waters in tidal swamps.

Flowers: Early summer
Fruits: Summer
Distribution: Rare in Australia, common in PNG and other parts of South-east Asia. It occurs only on Melville Island and the Cobourg Peninsula in NT and in Cape York as far south as the Herbert River delta
Uses: Aborigines have used the fruit as food

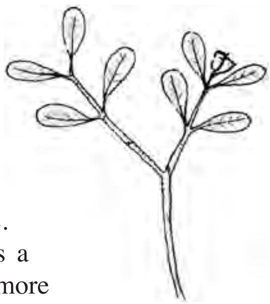
Nypa palm fruit

See first edition

Figure 143.1 *Nypa fruticans*

Osbornia octodonta

Family: Myrtaceae
Common name: Myrtle mangrove



In the northern part of its range, *Osbornia octodonta* may be a straggly tree up to 6 m high, but generally it is a bushy shrub or small tree. At its southern limit it is a shrub which rarely grows more than 1 or 1.5 m.

Bark is stringy, fibrous and dark in colour. The leaves, which are amongst the smallest of all the mangroves, are opposite, obovate, and sometimes are finely toothed at the leaf apex. But the most prominent feature is the smell of the leaves which, when crushed, exude an aroma of eucalyptus (it is a member of the same family as eucalypts). Flowers are creamy green.

O. octodonta is mostly found along the edges of the littoral zone, or fringing tidal watercourses. It does not occur in areas of frequent freshwater inundation.

Flowers: The second half of the dry season in the far north; early summer (Nov - Dec) in the rest of its range
Fruits: February into March
Distribution: As far south as Exmouth in W.A. Throughout the NT, and on the eastern coast of Queensland as far south as Tin Can Bay
Uses: As an insect repellent; Aboriginal uses include using heated branchlets to relieve toothache (Wightman 1989)

See first edition

Figure 143.2 *Osbornia octodonta*

Figure 144.1 *Pemphis acidula*
John Burnett

Pemphis acidula

Family: Lythraceae
Common name: Pemphis

Pemphis acidula is a straggly shrub or occasionally a small tree up to 3 or 4 m. Leaves are opposite, elliptical, small (10 - 20 mm long), covered on both sides by fine silky hairs, and crowded thickly on the twigs. Flowers are commonly white, but may be reddish or even green - yellow. Petals are wrinkled in a very similar manner to the garden tree, Pride of India, to which it is closely related.

P. acidula occurs at or just above the level of high tide. It will grow in sand, gravel and even rocky outcrops well above tidal influence. Like *Hibiscus tiliaceus, P. acidula* behaves as a terrestrial plant as well as a mangrove. Fruit is a small capsule, perhaps a centimetre in diameter, with a corky outer shell.

Flowers: All year round
Fruits: All year round, although according to Wightman (1989) peak fertility appears to be late winter through early summer
Distribution: *P. acidula* is widespread across the Kimberley coast of WA and the NT and extends down the Queensland coast to Sandy Straits
Uses: The timber is extremely hard. Aborigines have used branches to make digging sticks. In India, pestles and anchors have been made of *P. acidula*

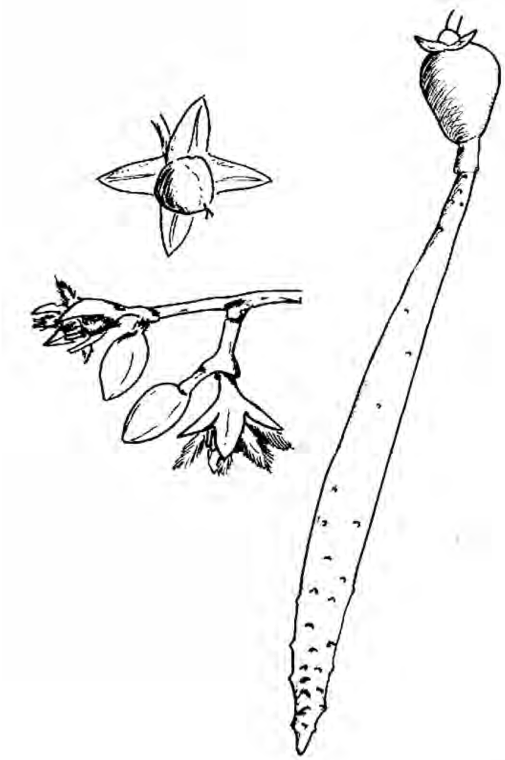
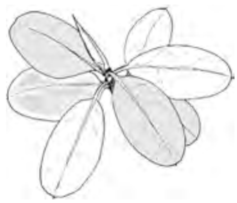


Figure 144.2 *Rhizophora stylosa* fruit
John Burnett

Rhizophora stylosa

Family: Rhizophoracea
Common names: Red mangrove, spider mangrove, stilt mangrove

R. stylosa is a tree which reaches 10 m sometimes, but is most often seen at 3 to 8 m.



The *Rhizophora* sp are probably the most spectacular of all the mangroves, with their distinctive robust prop roots. The long looping prop roots and the numerous aerial roots provide a large area over which lenticels (minute air holes) are scattered and through which respiration takes place.

Leaves are opposite, thick and somewhat brittle, with a small projecting point at the apex. On the underside of the leaf, numerous reddish brown glands are visible. Flowers are creamy white. Fruit is viviparous.

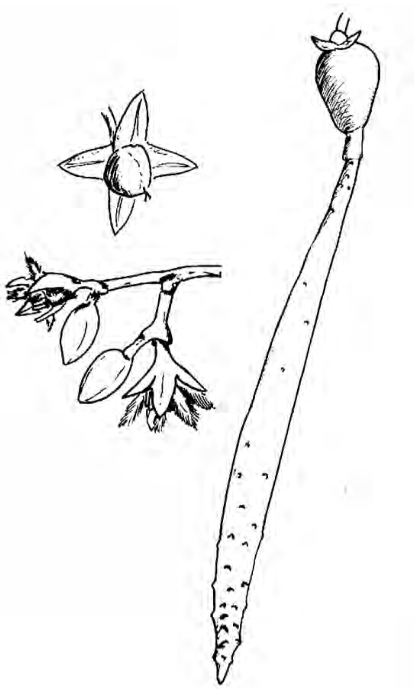
R. stylosa is a pioneer species and is found in vast monospecific stands on mudflats and on islands in tidal estuaries. It is found also in a variety of other tidal situations, in association with a range of other mangroves, but especially *Avicennia marina*, *Ceriops tagal* and *Bruguiera gymnorrhiza*.

See first edition

Figure 145.1 *Pemphis acidula* — a strandline mangrove

Bob Moffatt

Figure 145.2 *Rhizophora stylosa*



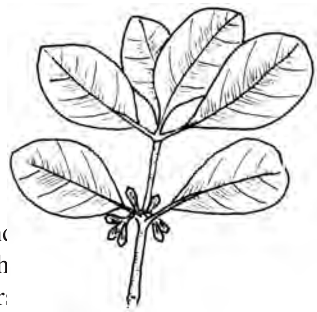
There are three other species of *Rhizophora* found in Australia, although *R. stylosa* is by far the most widespread. Differences are in the flowers and fruit. Other differences include the size of the tree, and to a lesser extent in habitat. *R. lamarkii* is a large tree reaching 25 m but is restricted to sand/mud substrates of perennial fresh water input.

R. lamarkii occurs across northern Australia, but not in WA. *R. apiculata* is also a large tree, reaching 15 m, which also likes plenty of fresh water. It tends to prefer deeper mud substrates in the middle zone. Its range is similar to that of *R. lamarkii*. *R. mucronata* occurs only on the North Queensland coast, in habitats similar to that of *R. apiculata*.

Flowers: Winter (June to September)
Fruits: Midsummer
Distribution: *R. stylosa* is widespread across northern Australia from Exmouth Gulf to Cape York, and down the eastern coast to the Richmond River in NSW
Uses: The timber is tough and durable. Aborigines have used it for implements such as spears and boomerangs. The bark is used for both tanning and is a source of dye. The wood is highly regarded as firewood

Scyphiphora hydrophylacea

Family: Rubiaceae
Common name: Yamstick mangrove



This is a small shrub which reaches to 5 m, but is most often seen as a straggly shrub of a metre or less. Leaves are opposite, obovate, small and glossy, almost as if polish and greyish on the under Between each pair of leaves are two triangular flaps of tissue called interpetiolar stipules, which are a characteristic of all family members. Young shoots are covered by a sticky resin. Flowers are white with pink centres and tubular in shape.

S. hydrophylacea occurs at the landward edge of mangrove zones and along the banks of tidal waterways. It tends to occur on mud or rock substrates in areas which are flooded only on spring tides (Wells, in Clough 1982). Wells further noted that this species occupies areas which are unsuited to other mangrove species.

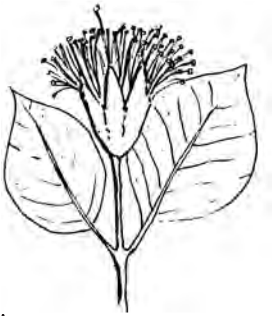
Flowers: Late winter through early summer
Fruits: Spring through midsummer
Distribution: Patchy occurrences from the Kimberley coast of WA across the NT to Cape York and down the eastern coast to Townsville
Uses: Wood is tough, and reported by Jones (1971) to be the true yamstick used by the Aborigines

See first edition

Figure 146.1 *Scyphiphora hydrophylacea*

Sonneratia alba

Family: Sonneratiaceae
Common name: Pornupan mangrove/ mangrove apple



A small bushy tree mostly 4 to 5 m high but occasionally reaching 20 m, *Sonneratia alba* has fine smooth bark which varies in colour from creamy beige to brown. Leaves are opposite, roughly elliptical, and fleshy but brittle.

This mangrove has numerous pneumatophores similar to those of *Avicennia*, but larger and much more robust. Jones (1971) noted that some which may be a metre high and branched at the apex have the appearance of small dead trees.

S. alba is a pioneer species, often associated with *Avicennia marina* and *Rhizophora stylosa*, sometimes with *Aegialitis annulata* as understorey. It tends to prefer soft sand and mud, and seems to be intolerant of lengthy periods of fresh water inundation.

Flowers: June to Sept
Fruits: October to February
Distribution: *S. alba* is widespread across northern Australia from the Kimberley coast of WA., through NT and down the eastern coast to the Broadsound/Port Clinton area
Uses: While there appears to be little evidence of Aboriginal usage of *Sonneratia* sp., both Wightman (1989) and Jones (1971) have noted a variety of uses through the rest of its range, including canoe building, use as medicine, and eating the fruit

See first edition

Figure 147.1 *Sonneratia* fruit and leaf

See first edition

Figure 147.2 *Sonneratia alba*

See first edition

Figure 148.1 *Xylocarpus granatum*

Another species, *Sonneratia caseolaris*, occurs sporadically across the NT and down the eastern coast as far south as Hinchinbrook Island. It does not occur in either WA or the Gulf of Carpentaria (Wells, in Clough 1982). It is taller than *S. alba,* with larger, thinner pneumatophores, and a very short leafstalk.

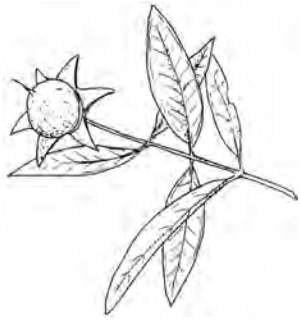


Figure 149.1 *Sonneratia lanceolata*

Xylocarpus mekongensis

Family: Meliaceae
Common name: Cedar mangrove

According to Wightman (1989) this is the same species which has been previously called *Xylocarpus australisicum*. It is a tree, up to 15 m high, with pneumatophores about the base of the tree which form conical knobs up to 400 mm high. Bark is a pale greyish brown which peels off in longitudinal flakes or scales. Leaves are compound, arranged in opposite pairs. Mature trees are partially deciduous in late winter. Fruit is cannonball shaped around 6 or 8 cm in diameter.

X. mekongensis occurs in forests fringing tidal waterways, and near the littoral edge of mangrove forests. Freshwater input is desirable for at least some part of the year.

There is a second species, *X. granatum*, commonly called cannon ball mangrove, which is distinguished from the preceding species by its plate-like pneumatophores and buttressing of the trunk, by its bark which is much darker and smoother, and by the fruit which is considerably larger.

Flowers: Spring through early summer
Fruits: Late summer through autumn
Distribution: From the Kimberley coast of WA across the NT and down the Queensland coast to the Great Sandy Straits/ Fraser Island region. *X. granatum* is rare in NT and WA
Uses: The timber is similar in colour and texture to red cedar to which it is closely related

See first edition

Figure 149.2 *Xylocarpus mekongensis*

Associated species

Some other plants that live with mangroves

Acrostichum speciosum

Family: Pteridaceae
Common name: Mangrove fern

Ferns generally are rare among mangroves — a few are found as epiphytes in the mangrove canopy but *Acrostichum* is unusual in that it occurs on the forest floor.

See first edition

Figure 149.1.3 *Acrostichum speciosum*

Figure 150.1 *Amyema cambagei*

Figure 150.2 *Amyema mackayense*

Figure 150.3 *Allocasuarina glauca* Swamp she oak

It has a short thick stem with pinnate fronds up to 1.5 m in height. Leaflets on fertile fronds are totally covered on their underside by reddish spore sacs. *A. speciosum* is widespread across the NT and the eastern coast into northern NSW. A second species *A. aureum*, which has blunter leaflets, is restricted to tropical regions.

Allocasuarina glauca

Family: Casuarinaceae
Common name: Swamp she oak or swamp oak

The swamp sheoak is regularly found at the landward edge of wetlands and mangrove areas. Although not a mangrove it has a very high salt tolerance, but does require freshwater input. Occurs quite often beside *Avicennia marina*, *Ceriops tagal* or *Excoecaria agallocha*.

Amyema cambagei

Family Loranthaceae
Common name: Sheoak mistletoe

This parasite has adapted its form to perfectly mimic its host with its needle-like foliage looking almost identical to the *Allocasuarina*'s foliage on which it grows. The leaves are greyish and covered in microscopic hair. Flowers are reddish followed by whitish spherical fruits which some birds relish.

Amyema mackayense

Family: Loranthaceae
Common name: Mangrove mistletoe

This is the common mangrove mistletoe that occurs right across northern Australia and down the eastern coast at least to the Sandy Straits. Leaves are rounded, 10 to 15 mm in diameter, opposite and succulent. It produces flowers and fruit throughout the year.

Drynaria rigidula

Family: Polipodiaceae
Common name: Basket fern

One of the few epiphytic ferns which also occur in the mangroves, *Drynaria rigidula* is common in the rainforests and on rocks and branches on littoral margins from north eastern NSW right across northern Australia.

Fronds may be up to a metre long, leaflets are irregularly serrated. Identification is aided by the fact that spores are arranged in raised single rows on either side of the central vein of each fertile leaflet.

This fern is a popular garden variety.

See first edition

Figure 151.1 *Drynaria rigidula* or basket fern found here on *Heritiera*

Derris trifoliata

Family: Fabaceae
Common name: Derris vine

A climber, often rambling, and a creeper when no support is available, *Derris trifoliata* is widespread across northern Queensland and the NT. It has compound leaves in groups of five or sometimes three (hence the name); producing white pea-like flowers and flattened kidney-shaped fruit. Cape York Aborigines used *D. trifoliata* as a fish stupefying agent. The insecticide 'rotenone' is derived from a South-east Asian species of *Derris* (Wightman 1989).

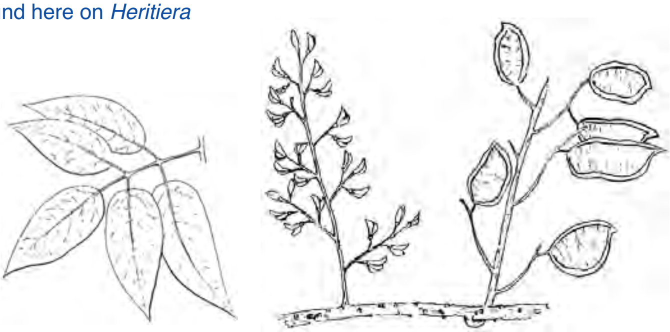


Figure 151.2 *Derris trifoliata*

Enchylaena tomentosa

Family: Chenopodiaceae
Common name: Saltbush, Tomato bush, ruby salt bush

This plant usually grows close to the ground and has smaller leaves than *Suaeda australis*. It produces bright red shiny fruit usually in the earlier part of the year. These are sweet to eat. This plant also occurs in saline 'desert' areas in central Australia. Its leaves store salt the same way that both *Suaeda* species do.

See first edition

Figure 151.3 *Enchylaena tomentosa*

Figure 152.1 *Microsorium punctatum*

Figure 152.2 *Pallandsia usniodea*

Figure 152.3 *Ramalina* (on a grey mangrove)

Microsorium punctatum

Family: Polipodaceae
Common name: Microsorium

This medium-sized fern is common from coastal ranges to shoreline throughout northern Australia to at least as far south as the Hervey Bay area.

It inhabits a variety of substrates, including rainforest edges and along rocky and sandy at the outer edge of the littoral zone. Fronds are up to 1.2 m long with a pale central vein which is raised on the upper leaf surface. Being a hardy tropical species, it will withstand full sunlight, but is susceptible to frost. This is a limiting factor to its range.

Microsorium punctatum and its close relative *M. scandens*, called the fragrant fern because of its mushy odour, and which is also a sometime littoral zone inhabitant, are popular outdoor garden plants.

Pallandsia usniodea

Family: Bromiliaceae
Common name: Old man's beard

Old man's beard is an introduced species, an escapee from the garden, a native of the Americas. A relative of the pineapple, it is tolerant to a wide variety of climatic types and habitats (J. Thomas, pers.comm 1993). It occurs on both *Avicennia marina* and *Rhizophora stylosa* in the Hervey Bay area, and might be found in other areas near urban centres throughout Australia.

Ramalina species

Common name: Lichen

This is a common species growing mostly on the bark of the grey mangrove (*Avicennia marina*).

Lichens are plants that are a 'combination' of fungi and algae in a symbiotic relationship. Nutrients are absorbed from the air and also to an extent from material washed over them from the bark of the plant they grow on. They produce spores from small cup-like fruiting bodies. Their tissues are fairly absorbent causing their usually stiff tissues to become soft during wet weather. This lichen has flattened greyish stems and can grow to about 200 mm long but should not be confused with the exotic weed *Pallandsia* which is not a lichen but actually a bromeliad.

Other lichens

Various lichen species grow on mangrove tree branches, twigs and trunks. Colours can be grey, white, yellow,

Figure 153.1 Lichens on a grey mangrove

Figure 153.2 *Suaeda arbusculoides*

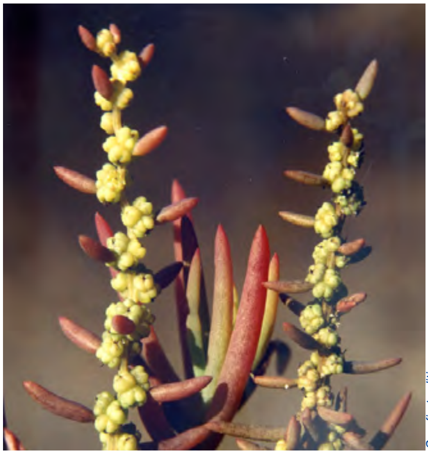


Figure 153.3 *Suaeda australis*

Figure 153.4 *Samphire*

orange, brown, red or black. Some grow as tufts like a ball of fur while others form skin-like growths on bark, making the tree trunk look mottled.

Suaeda arbusculoides

Family: Chenopodiaceae
Common name: Jelly bean plant or a samphire bush

A plant with distinctively shaped miniature 'jelly bean' shaped leaves. It only grows to about 450 mm tall and is common in saline areas. Its adaptation to dealing with a saline environment is typical of these types of plants in that leaves store salt and wither and drop off when salt concentration within the tissues reaches 'saturation' point.

Suaeda australis

Family: Chenopodiaceae
Common name: Saltbush or a samphire bush

This plant and *Enchylaena tomentosa* can be easily confused but this one differs by being upright in its growth habit, growing to about a metre tall at times and spreading almost as wide. Like the jelly bean plant, its leaves store salt, gradually changing colour from green to yellow to orange to red as salt concentration increases, then withering and dropping off, thus shedding the salt.

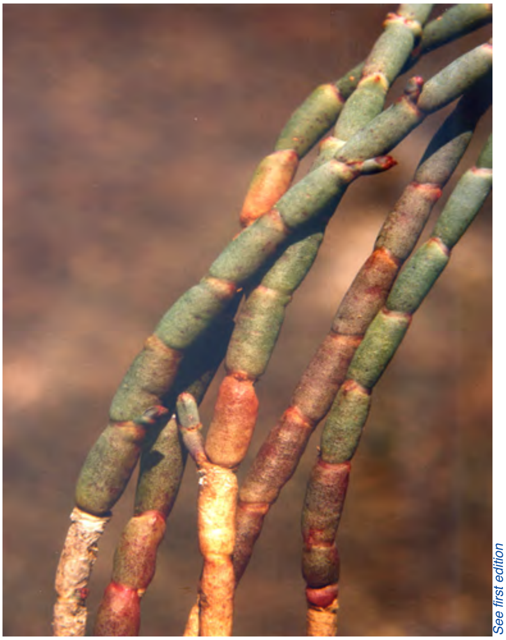


Figure 154.1 *Sarcocornia quinqueflora*

Figure 154.2 *Sesuvium portulacastrum*

Figure 154.3 *Saltwater couch*

Sarcocornia quinqueflora

Family Chenopodiaceae
Common name: Beadweed, tree samphire

A fleshy plant that forms dense 'shagpile carpets' in saltmarshes. Flowers are almost microscopic in size and are white. Like most other succulent salt marsh plants, its leaves store salt. Leaves with high salt concentrations turn orange or red. The strings of foliage resemble strings of beads, hence the common name.

Sesuvium portulacastrum

Family Aizoaceae
Common name: Sea purslane

A fleshy plant that forms 'carpets' or 'mats' in sunny areas especially in salt marshes. Stems are red or orange and the flowers are pink. The leaves store salt as for the *Suaeda* species and *Enchylaena*. In 1770, Captain Cook's men collected this plant in sufficient quantities whenever coming ashore to cook as a vegetable to help avoid scurvy.

Sporobolus virginicus

Family: Poaceae
Common name: Saltwater couch, saltcouch

Saltwater couch is widespread throughout the warmer parts of the world and is found in all States of Australia. It occurs in salt marshes and wetland areas, often on the saltflats and margins behind mangrove forests; in many cases in association with *Allocasuarina glauca* (swamp sheoak), or with *A. equisetifolia* (coastal sheoak) behind sandy beaches.

Thespesia populnea

Family: Malvaceae
Common name: Portia, Indian tulip

A tree which is related to hibiscus, the two species are very similar and often occur together.

However it differs from *Hibiscus tiliaceus* in two easily identifiable respects — the leaves do not have the fine hairs on the underside, and the flowers are plain yellow.

It occurs commonly on the Queensland coast; another of the species, *T. populnoides* also occurs in Queensland, and is widespread across NT and north-east WA. *Thespesia* sp. are popular ornamental trees.

Appendix 2

Glossary

Adaptation: any aspect of a mangrove that promotes its welfare or the general welfare of the species to which it belongs. Some of the aspects which create problems for mangroves are salt, mud, getting enough air or moving seeds around.

Aerial roots: see diagram opposite

Algae: simple single or multicelled plants.

Alternate: (as in leaves) arrayed one by one along a stem - not opposite.

Anaerobic: living in an environment which lacks free oxygen.

Anoxic: without oxygen.

Apex :summit or tip.

Axil: the angle between the upper side of the leaf and the stem; the normal position for lateral bends.

Bark: outer covering of the stem or the root.

Bisexual: bears both male and female sex organs in the same flower.

Bulbous: swallow or bulb shaped.

Buttress: ridged extension of a tree trunk at the base.

Calyx: outer whorl of the flower, consisting of sepals.

Canopy: foliage cover.

Capsule: dry fruit containing a number of seeds.

Carbohydrates: complex molecules made up of carbon, hydrogen and oxygen (eg. sugar or starch). They are the main energy source for marine life.

Cellulose: complex chain of sugars and carbohydrates.

Chemosynthesis: a process where inorganic substances such as iron, nitrogen or sulphur are used to make carbohydrate.

Ciliate: a microscopic, one celled organism that has many hairlike projections covering their outer surface. These cilia move in a uniform motion to allow locomotion and obtain food.

Community: the term given to any naturally occurring groups of organisms inhabiting a common environment.

Complex molecules: example is cellulose $(C_6H_{12}O_6)_n$ where n is a large number

Compound leaf: a leaf divided to the mid-rib into smaller distinct leaflets.

Consumer: an organism in a food chain which feeds on and obtains energy from the one before it.

Cotyledon: leaf developed inside a seed; seed leaf.

Crustacea: class of Arthropoda which includes prawns and crabs, sometimes considered a Phylum.

Deciduous: sheds leaves at the end of the growing season, opposite of evergreen.

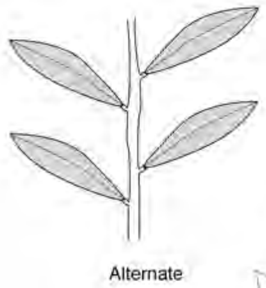
Detritus: organic matter from decomposing plants and animals.

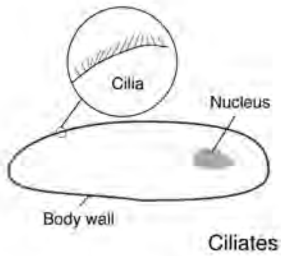
Diatoms: single celled plants which grow in marine or fresh water by dividing in two and characterised by a silica shell, part of the phytoplankton.

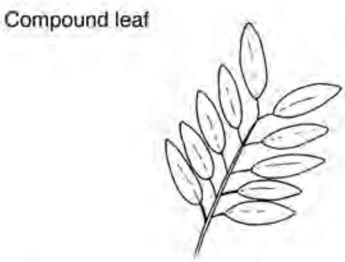
Diffusion: a random movement of particles resulting in a movement from a high area of concentration to a low area of concentration.

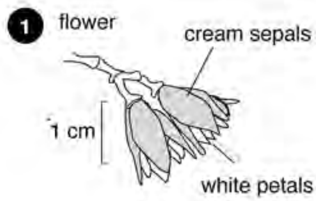
Dinoflagellate: another type of phytoplankton characterised by two flagella

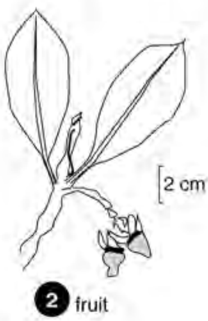
Ecology: the study of the relationship of plant and animal communities to their surroundings.











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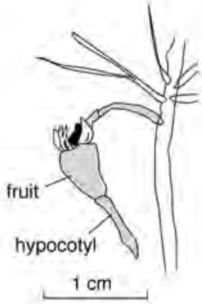


3 germinating fruit

4 fully developed hypocotyl

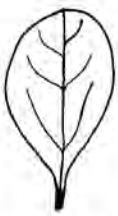

Bipinnate

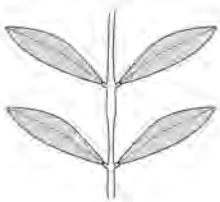

Linear


Ovate


Lanceolate


Elliptical


Obovate


Opposite

See first edition

Ecosystem: a community of organisms interacting with one another, together with the environment in which they live, and with which they also interact.

Epidermis: outer layer of cells of a plant or animal, one cell layer thick.

Epiphyte: a plant attached to another plant, using it for support and not growing parasitically eg: orchids.

Family: one of the groups used in classifying organisms; similar families are grouped in an order. In botany the name of a family ends in - ceae.

Flagellate: microscopic free moving organism whose means of locomotion is by a rapidly moving flagella eg. *Noctiluca* sp.

Floristics: the study of the composition of vegetation in terms of the species, or flora, present.

Food chain: the chain of organisms existing in a community through which energy is transferred; green plants are the base of the food chain, and support all the consumers.

Frond: leaf of palm or fern.

Gastropod: class of mollusca including univalves such as snails.

Genera: plural of genus.

Generic: referring to a genus.

Genus: one of the groups used in classifying organisms, similar genera are grouped in one family.

Germination: the growth of a seed or spore to produce a new plant.

Habitat: natural abode of a living organism.

Halophyte: a plant which can tolerate saline conditions.

Hypocotyl: part of a seedling stem below the cotyledons.

Hydrogen sulphide: a foul smelling gas produced as a waste product of chemosynthesis by bacteria.

Interpetiolar: between the leaf stalks.

Intertidal: below high and low tide levels.

Isopoda: order of Crustacea with seven pairs of legs almost identical in length - mostly marine.

Knee roots: knobbly projections of lateral root systems in *Bruguiera* sp.

Lanceolate: (as in leaves) lance shaped, broadest in the middle and tapering towards each end.

Lateral: on the side or edge.

Latex: white sap exuded from some plants.

Leaf litter: an accumulation of leaves and organic matter fallen from trees.

Lenticel: porous area on the outer layer of a stem - used to facilitate exchange of gases.

Littoral: near the sea.

Mesophyll: internal tissue of a leaf blade.

Mid-rib: main vein of a leaf, running from base to tip.

Molluscs: soft bodied mostly marine animals (mostly with a hard shell or shells of calcium carbonate.

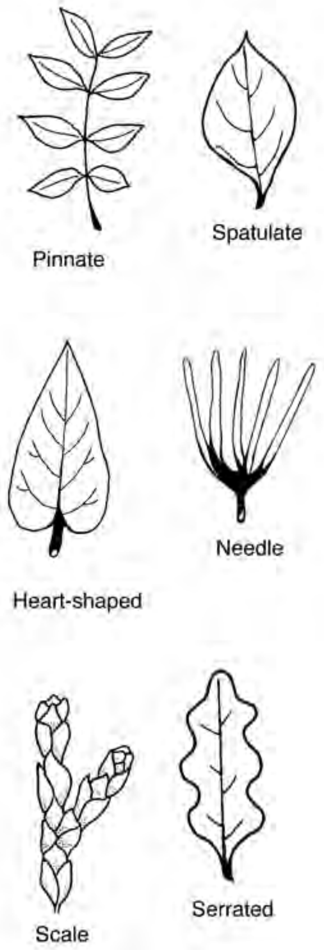
Nutrients: materials needed for organisms to live.

Obovate: (as in leaves) broadest towards the tip of the leaf.

Opposite: (as in leaves) in pairs, one at each side of the stem.

Ovate: (as in leaves) egg-shaped; broadest nearer the base.

Oxygen levels: the amount of oxygen present in the water or mud.



pH: a measure of the acid or alkali in the mud

Pelagic: describes organisms which inhabit the mass of seawater in contrast to those on the seafloor; generally refers to fish species which inhabit the upper layers.

Petiole: stalk of leaf

Photosynthesis: the process by which water and carbon dioxide are synthesised to form organic compounds using energy absorbed from sunlight by chlorophyll in leaves.

Pinnate: compound leaves in which the leaflets are opposite.

Pioneer: plant species which occurs early in the development of vegetation in a given area.

Plankton: plant or animal drifters in the surface layers of a body of water; most are microscopic, but some may be macroscopic.

Pneumatophores: special roots produced by some plants which grow in tidal wetlands; important in plant respiration.

Pod: dry, opening, multi-seeded fruit.

Productivity: the rate by which solar energy is absorbed in the photosynthetic production of organic matter; net productivity is the excess of photosynthesis over respiration.

Prop roots: roots growing downwards from the trunk of a tree and which support the tree.

Rhizome: a stem which is usually underground, producing new shoots and roots.

Riverine: situated beside a river.

Salinity: the amount of salt dissolved in water. Most of the salt in the sea is sodium chloride. The average salinity of the sea is about 35 grams /per litre of salt. Salt which accumulates in mangroves creates a problem for the plant and needs to be regulated by exclusion, extrusion or accumulation.

Seagrasses: flowering marine plants that grow on the sand and mud banks underwater and help stabilize them.

Shrub: plant community dominated by shrub and small trees.

Sepal: segment of the calyx of a flower.

Species: The basic unit of biological classification.

Spore: reproductive cell without an embryo.

Stamen: pollen producing organ of a flower

Stipules: small leaf-like appendages which may be found on either side of the leaf stalks on some plants.

Substrate: the soggy or sandy soil in which the mangrove grows. The substrate can vary from mud ooze to quite firm soil.

Succulent: (as in leaves) soft, fleshy leaf which almost always has a high water content.

Sulphur bacteria: bacteria that use sulphur and sulphur compounds for chemosynthesis to manufacture carbohydrates.

Sulphates: a basic chemical ion (SO_4^{2-}) found in the mud.

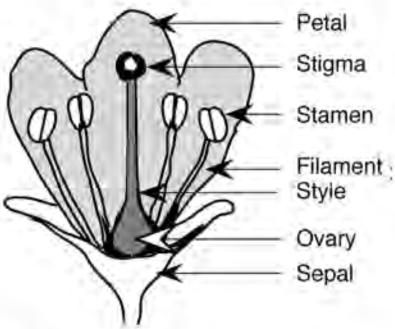
Terrestrial: plants which grow in the ground or animal organisms which live on the ground; not marine or aquatic.

Understory: lower strata of plants in a community.

Vivipary: (of plants) seeds which germinate in the fruit before dispersal from the parent plant.

Vein: the appearance of vascular tissue in a leaf.

Whorl: a group of three or more structures encircling an axis at the same level.



General flower anatomy

See first edition

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The Mangrove Resource Hub
Student Pre-visit Booklet

https://sites.google.com/education.nsw.gov.au/mangroveresourcehub

The Mangrove Resource Hub was developed to support students to investigate the mangrove ecosystem by providing resource material to:
1. prepare for the fieldwork program (pre visit)
2. develop a depth study (optional)

The activities of the resource hub and fieldwork program support Module 3 - Biological Diversity and Module 4 - Ecosystem Dynamics of the Year 11 Biology syllabus

Marvellous Mangroves Australia
A Wetlands Education Resource Book for Australia

https://mangroveactionproject.org/wp-content/uploads/2024/06/Australia-Marvellous-Mangroves.pdf

Marvellous Mangroves – a guide for teachers that will provide a complete understanding of mangrove ecology, and support the conservation of the vitally important ecosystems provided by these remarkable trees.

This workbook is aimed mostly at students aged 8 to 13 (Grade 4-8), although the materials can be made more sophisticated for older grades.

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