CONSERVATION AND BIOLOG

(Avicennia marina) on the Lesc

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Western Australian Marin

Southern estuary, Leschenault; looking from the no

Conservation

The Leschenault Estuary is the only locality where the white mangrove, normally considered as a tropical species, is known to occur in the south of Western Australia. The two small stands of mangrove on this estuary are very vulnerable to the developmental whims of man.

Mangroves fringe the northern bank and Anglesea Island opposite the town of Bunbury, on the southern end of the estuary. Immediately adjacent to this stand is the new massive deep-water harbour development, the embankments of which separate this southern part of the estuary from the major northern reach. Between the mangroves, the northern bank, and the southern harbour embankment is a small ponding used to dump effluent from a nearby plant which extracts ilmenite from beachsands. The ponding does not appear to have affected mangroves close by (although the very few mangroves in the basin have died). At present these mangroves are more threatened by a proposal to straighten the estuarine channel so as to provide an extra few hundred metres for a 1,000 metre rowing course. There is also a proposal to bulldoze and fill the salt marsh backing the mangroves, so as to "control" mosquitoes.

The northern stand of mangroves is even smaller and is located on the isolated western shore of sand dunes, near the head of the estuary just north of Waterloo Point. Possibly careless upgrading, by bulldozing, of the track abutting the shoreline fringed by the mangroves, places the mangroves in constant jeopardy. Thoughtless destruction of natural areas, e.g. by unsupervised bulldozing, is being increasingly decried by many people.

In the present climate of ecological awareness, any development expected to adversely affect natural areas should not be allowed to proceed without reasoned argument, seeking to find an effective compromise for action, based upon the values of the proposed development and of the natural conditions (Morrissy, 1970a). In the area in question this democratic process is effectively undertaken by the Leschenault Estuary Conservation Committee, the members of which represent many points of view. For example, a proposal has been received for eradication of the salt marshes backing the mangroves in the southern part of the estuary which have been blamed for breeding the salt tolerant larvae of a mosquito, *Aedes vigilax,* the adults of which are a pest to the town people of Bunbury. However, Hodgkin and Smith (1971) have advised the above committee that breeding is not likely to occur in parts of the swamps which are regularly inundated by the tides. **But** where stagnant pools have been dug or enclosed by dumping and filling, as has been done in some places around the estuary, breeding does occur and, therefore, attention should be focused on these localities.

The social merit of a rowing course of Olympic standard near Bunbury must be weighed against the loss of part of the present southern stand of mangroves. However, there is a possibility that any losses of mangroves could be offset by creating suitable intertidal banks where seedlings could be planted in other places.

Biology

The word mangrove has an obscure origin; it is a combination of the Portuguese "mangue" and the English "grove". "Mangrove" is used either to describe an association of floristically diverse trees and shrubs **which grow in the intertidal region**

)GY OF THE WHITE MANGROVE

eschenault Estuary near Bunbury

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northern bank south towards the town of Bunbury.

of the sea, characteristically forming the lower part of the coastal vegetation of many tropical and sub-tropical areas, or it may be applied to an individual species of these trees such as *Avicennia marina* (MacNae, 1967; Connor, 1969).

In southern Australia there is only one species of mangrove, *Avicennia marina.* Its existence in Western Port Bay (latitude 38° 20′S) near Melbourne, St. Vincents and Spencer Gulfs (32° 30′S-34° 50′S) in South Australia, and near Bunbury (33° 20′S) represents the southern extremity of a distribution centred in tropical regions where many different mangrove species form vast areas of swamps and forest (Adams, 1969). Mangroves occur on tropical shores from the ever-wet to desert, i.e., from regions of high rainfall and high humidity to regions of low rainfall and excessive evaporation. Along desert coasts only one or two of the most hardy mangrove species survive. *Avicennia* occurs along the shore of the Red Sea (MacNae, 1966). Extensive mangroves occur around the northern shore of Australia, at all suitable localities between Houtman Abrolhos and Shark Bay in W.A. and the Queensland-N.S.W. border.

Avicennia is thought to be limited in its southward dispersal by low temperatures. Two hypotheses are put forward for its presence in southern Australia (MacNae, 1966). Firstly, its presence may be explained by the drift of floating fruits in known currents southward from the northern regions and across the southern coast from west to east. However the short life of the floating hypocotyl makes this hypothesis unlikely. Secondly, the three patches of *Avicennia* in southern Australia may be relics of past geological eras when the climate was warmer than it is today and *Avicennia* may have persisted in these especially favourable sites from the late Tertiary (about one million years ago). Beard (1967) has discovered an extensive stand of mangroves on a saline inland creek, isolated from tidal action, in the northwest of W.A. along the 80 Mile Beach He suggests that this occurrence is a relic of estuarine conditions prevailing at the time of maximum eustatic rise in sea level which occurred about 4,000 years ago.

Avicennia is a tree which is specially adapted to cope with salt and periodic flooding by tides (Adams, 1969). Water conducting tissue in the stem can almost completely desalinate saltwater. The leaves have epidermal glands which excrete salt. The tree has an extensive shallow root system, sensitive to erosion or sand deposition, which supports upright air-filled pneumatophores or aeration roots. At the base of these roots shallow nutritive roots form an interweaving mat, some 20-40 cm. below the surface of the fertile mud. On shores of high salinity the root system is more extensive and the aerial roots form copses up to waist height.

The seeds of *Avicennia* is viviparous, i.e. the young seedling grows out of the seed before it is released from the parent tree. This is an adaption to the salty conditions on the shore for the very young seedlings are not very tolerant of salt unlike older stages (see later).

Mangroves form the most seaward zone of the shore vegetation subjected to tidal flooding to a greater or lesser degree. According to MacNae (1966) mangroves occur between the extreme high-water mark and a level above but close to mean sea level. Some trees are surrounded by seawater only once or twice a year but the others usually have their bases inundated daily. Adams (1969) states that *Avicennia* (in contrast to the salt marsh) at Western Port Bay is right in the tidal water, and twice each day its breathing roots (pneumatophores) are exposed to the air. The mangroves here mark the limit of the high tides. Patton (1942) observed that the junction between the mangroves and the salt marsh, landward behind it, is sharp where the banks are steep. Where the slope is gradual, however, the junction is not so well-defined and some of the marsh plants are regularly covered by the tide, although the depth of water is not great. The mangrove zone is seldom more than one or two large trees in depth. In front of these trees thickets of saplings and seedlings extend out onto the beach.

Mangroves promote a great stability of littoral mud flats because of their extensive shallow root system (MacNae, 1963). There is a tendency for one bank of an estuary to be an erosion bank and the other a bank of deposition (of silt, etc.), e.g. the southern and northern banks of the Leschenault Estuary close to Bunbury. The bank of deposition is colonized by *Avicennia*.

Avicennia marina.

The settlement and establishment of the seedlings appears to be the most critical stage in the life-cycle of *Avicennia marina*. MacNae (1966) states that many of the seedlings at the lowest (seaward) level can have their leaves covered by a layer of fine mud deposited by the tide, and they soon die if this occurs. Saplings also die if shaded by their parents and can develop to full maturity only if they are exposed fully to the sun.

[Clarke and Hannon (1971) have recently shown experimentally that MacNae's (1966) observation is incorrect. Growth of seedlings is noticeably reduced only in deep shade. Under partially shaded conditions growth is less rapid but the seedlings are much healthier than in full light.]

Clarke and Hannon (1969, 1970) have examined survival of seedlings near Sydney where diurnal flooding occurs daily in the lower parts of the mangrove zone. The frequency of diurnal flooding in the upper parts of the zone is lowest in December and January when the seedlings fall. They say that this phenomenon is undoubtedly significant in seedling survival and that the majority of the seedlings fall in the landward part of the zone. The young seedlings tend to become established among pneumatophores of their parents where the tidal scour is least. The seedlings' roots take approximately 5 days to become firmly established and seedlings uprooted after this time usually die. Therefore a greater number of seedlings may be expected to survive if establishment occurs in conjunction with a period of lower than average tides. Although the seedlings require the moist humid conditions provided by regular tidal action during their early growth, tidal action limits the seaward extension of mangroves because the seedlings cannot grow in completely submerged conditions.

Clarke and Hannon (1969) after extensive field observations of soil salinity, water table level, drainage and aeration as determined by tidal movement and the microtopography of an area, considered that the survival of young *Avicennia*, and hence the presence of mature trees, was largely determined by their tolerance of salinity and water-logging. They then (Clark and Hannon, 1970) performed glasshouse experiments to determine the tolerance of young trees. Freshly fallen seedlings of *Avicennia* can be obtained at the suitable stage for transfer (with 0-2 leaves) from the field for only about one week in each year near Sydney. A vermiculite culture saturated with 25% seawater was used to grow the seedlings to the 2-4 leaf stage. The solutions were renewed at two-week intervals but not aerated. Covering the culture vessels with inverted plastic bags improved growth since the seedlings were then exposed to higher humidities.

At the 0-2 leaf stage *Avicennia* requires seawater for optimal growth, particularly for root development. After the cotyledons had dropped, the seedlings grew well for several months in seawater and diluted seawater without an external nutrient source, although the greatest growth occurred in 20% seawater plus nutrient solution. Concentrations above 60% seawater retarded growth. Very few seedlings were able to tolerate more than 100% seawater for more than a few weeks, and no leaves were produced when more than 125% seawater was used.

Seedlings at the 2-4 leaf stage were more tolerant of higher salinities than the younger plants. The best growth of these older seedlings occurred with 40% seawater plus nutrient; 85% survival occurred in 100% seawater.

Pneumatophores in mud.

Extreme water-logging, including total immersion, of the very young (0-2 leaf stage) seedlings resulted in a high mortality but survivors, after passing through an unhealthy period, grew into plants as healthy and almost as large as those in the less water-logged treatments. Seedlings that had already developed 2-4 leaves were not adversely affected by water-logging.

Connor (1969) also found that the optimum level of salt for *Avicennia* occurred at about half the concentration of seawater. Connor concluded that the normal habitat of this species reflects its tolerance to high levels of salt rather than an optimum adaptation to it. However, by comparison with the other vegetated intertidal zones, the mangrove zone shows least variation in soil salinity on a seasonal basis due to the regular tidal flooding over it. The more landward zones show larger variations in soil salinity due to the more prominent effects of evaporation and freshwater drainage. The more frequent inundation of the mangrove zone keeps soil salinity close to that of seawater and satisfies the mangrove's metabolic requirements for salt and water.

Young saplings—seedlings of *Avicennia marina* colonizing the new embankment of the pondage for ilmenite.

Clarke and Hannon conclude that the seaward limit to the belt of mangroves bordering the sea is determined by tidal action on seedlings. Landward, high soil salinities for long periods, or wide variation in salinity and lower humidities, due to the more marked effects of evaporation, freshwater drainage, wind action and high temperatures with decreased frequency of tidal flooding, limit the further spread of the mangroves.

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