THE FAUNA OF MANGROVES

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The fauna of mangroves basically reflects the convergence of two types of habitat, a sheltered marine muddy intertidal habitat and a terrestrial forest. In temperate areas, mangroves form fairly open, one layered forests; in tropical areas they may be open or closed, often multilayered with distinct zonation. The terrestrial fauna is to a large extent, restricted to the forest canopy and the marine fauna to the substrate and lower levels of the forest, so a horizontal partitioning of the two dominant kinds of fauna occurs. A third component, a freshwater fauna may be present along the margins of the mangroves in the upper reaches of the estuary.

Within the two major faunal components, subdivisions occur. For the terrestrial fauna, this may be related to the zonation of the mangroves themselves. For example certain species of insects are restricted to particular mangrove trees, e.g. the butterfly *Hypochrysops epicurus* is restricted to *Avicennia marina*. The terrestrial fauna may also be affected by the type of vegetation adjacent, this may be *Melaleuca*/eucalypt forest, *Juncus* sedgelands, *Melaleuca* swamps; rainforests or bare salt plains. In some cases, mangroves may provide the only refuge for terrestrial species, in others they serve as a corridor linking adjacent habitats.

The terrestrial fauna may be modified by the presence of any permanent freshwater, frequency of flooding and rainfall which will determine water availability and its distribution at critical times of the year for migratory and permanent residents. For example all the mosquitoes and biting midges require permanent pools of water for breeding.

Terrestrial species often utilise mangroves as secondary rather than primary habitat. Insects may be attracted into mangroves when certain species are flowering. Flying foxes *(Pteropus poliocephalus, P. alecto)* come into the mangroves to feed on the blossom and often camp (roost) in the mangroves. These camps attract pythons *(Liasis fuscus* and *L. olivaceus)* which feed on the flying foxes. Some species of birds utilise mangroves as feeding and roosting grounds during migration (south eastern Australian populations of the rufous and grey fantails, *Rhipidura rufifrons* and *R. fuliginosa)*. Others such as the Torresian imperial pigeon *(Ducula spilorrhoa)* and pied cormorant *(Phalacrocorax varius)* breed in mangroves benefiting from the isolation of mangroves stands. Others may use mangroves during the winter or in drought conditions. For most of the terrestrial fauna, the tidal cycles are not important in determining their distribution; except for species which feed on the forest floor like the small white bellied rat *Xeromys myoides* which feeds on crabs. Other small marsupials and reptiles may move across the forest floor during low tide but move through the canopy at high tide. So that for most of the terrestrial fauna, some indication of their likely distribution patterns can be obtained by looking in nearby terrestrial forest. Whether some species expand their habitat in mangroves, where fewer species may occur than in their primary habitat is at the moment unclear but worthy of further investigation.

The marine fauna is vertically zoned both across the substrate and up the tree trunks in response to tidal cycles and drainage patterns. Obviously any streams flowing into the mangroves will also affect zonation. Behavioural, morphological and physiological adaptations of the fauna are critical in determining the tidal levels at which a species can live. Other factors such as the density of pneumatophores, seedlings and leaf litter together with salinity gradients along the river are also important. Particular mangrove species may be critical for selective herbivores or in providing microhabitats by their type of trunk or aerial roots. Finally, the zonation patterns of the fauna may vary within a tidal cycle and or during the life cycle.

For both the terrestrial and marine fauna, latitudinal gradients along the coast are superimposed on local zonation patterns. Variations in the hinterland affect rainfall, drainage patterns and run-off. The run-off will determine the terrestrial sources of nutrients and modify the salinity gradients. Finally, small stands of mangroves may have very different faunas from those of large stands. For these larger stands may provide sufficient refuges for some of the fauna to survive during flood conditions when heavy mortality of the mangrove fauna occurs. Other factors may also be responsible for the large seasonal and yearly variation amongst the mangrove fauna populations, which are beginning to appear in the literature.

A synthesis of the fauna of Australian mangroves is obviously not possible in this short article but is currently being attempted by Hutchings and Recher (in manuscript). The existing data poses certain problems. The fauna is extremely diverse, however many studies have concentrated only on one or two groups and many groups have been almost completely neglected, such as ants, beetles, and microcrustaceans. Similarly many geographical areas have been little studied. Quantitative data or data on the zonation of animals is almost non existent and what is available is difficult to compare as various sampling techniques have been used. Seasonal variations have rarely been taken into account. However, in the remaining part of this article I will attempt to give an impression of the diversity of fauna present.

Few terrestrial vertebrates are restricted to mangroves. The majority are casual visitors, including mammals, birds and reptiles. Mammals seen in mangroves include several species of rats and mice, bandicoots, possums, swamp wallabies, and wild pigs. Flying foxes are commonly seen especially in tropical areas. Some species of tree roosting bats also occur occasionally.

Birds are a conspicuous component of all mangrove forests. Over 200 species have been recorded from Australian mangroves and 14 of these are virtually restricted to this habitat. Another 12 species use mangroves as primary habitat in part of their range and for about another 60 species mangroves are an important habitat. Southern temperate mangroves lack any endemic bird species. Around 34° S, the latitude of Sydney, the first endemic species occurs, the mangrove heron *(Butorides striatus)* and the mangrove warbler *(Gerygone magnirostris)* occurs from Newcastle northwards. The greatest number of mangrove endemic birds (13) occurs in N.W. Australia.

Heloecius cordiformis (Semaphore Crab) scavenging at the base of an *Avicennia* pneumatophore.

Several species of snakes and goannas are commonly seen feeding on crabs and small fish in tropical mangroves. Frogs are rarely seen in mangroves, and appear to be restricted to freshwater/marine interface in tropical areas.

In contrast the terrestrial invertebrate fauna is incredibly diverse but very poorly studied, especially the beetle and weevil fauna which are commonly associated with fallen logs and leaf litter. Termites and ants are common in tropical stands. Some of the ants build nests at the low water mark but exactly how they survive tidal inundation is unknown. Many species of Diptera and Lepidoptera occur, and they range from species restricted to particular mangrove species, often laying their eggs in specific mangrove fruits, to generalists species which may feed on a wide variety of mangroves. The only well studied groups of mangrove insects are the mosquitoes and biting midges *(F. Ceratopogonidae)* often erroneously called sand flies. The three common mosquitoes are *Aedes vigilax, A. alternans* and *Culex sitiens*. The biting midges are more diverse and there are about 20 species associated with this habitat, many undescribed and for most, only the adult form being known.

Spiders are a conspicuous part of the terrestrial fauna. To date no mangrove endemic spiders have been found. The most common group are the orb web-building spiders. Another group, the wolf spiders *(Geolycosa* sp.) and allied hunting spiders of the family Pisauridae *(Dolomedes* sp.) occur on the ground or amongst the lower storey of vegetation.

The most conspicuous aquatic vertebrates are the salt water crocodiles *(Crocodylus porosus)* which occur potentially in all river systems from

Broome in Western Australia across the Northern Territory to Maryborough in Southern Queensland. Crocodiles feed within the mangroves but do not nest in them. Sea snakes are commonly seen on the rising tide in tropical mangroves.

The best represented group of fish living in mangroves belong to the gobiid subfamily Oxcidercinae which includes the mud skippers of which there are about five species in two genera *(Periophthalmus* and *Periophthalmodon)*. Other groups of gobies also occur, but they are not restricted to mangroves; they occur in other estuarine areas.

The aquatic invertebrates consist of abundant micro-invertebrates such as nematodes and protozoans which have been almost completely neglected and a diverse fauna of macro-invertebrates, well represented by molluscs, crustaceans and polychaetes. This fauna can be conveniently divided according to habitat:

1. Substrate epifauna including many molluscs.

2. Substrate infauna, dominated by sedentary bivalve molluscs and polychaetes and a rich mobile crab fauna. The crabs move over the substrate to feed but must remain near their burrows which because they extend below the water table, always contain water. This water is vital for respiration as the gills can only take up oxygen dissolved in water, and for some types of feeding. Sedentary sipunculans are a very characteristic component of this fauna in tropical regions.

3. Encrusting fauna on the surface of pneumatophores and tree trunks. This fauna is restricted to the seaward margins of the mangroves and is dominated by the filter feeding oyster, *Saccostrea commercialis*. In amongst the oysters, small crabs, shrimps, gastropods and polychaetes may occur in the moist environment.

4. Fauna associated with fallen logs. Although this fauna is not restricted to mangrove habitats it is common as logs tend to become trapped within the mangroves. Recently, a close association has been demonstrated between marine fungi, some wood boring beetles, and the marine borers such as ship worms (teredinids) and wood boring isopods. The fungi seem to prepare the wood and facilitate boring by the animals. Once the wood borers have created the maze of tunnels other species "nestlers" appear such as small shrimps, crabs, gastropods and polychaetes.

5. Mangrove epifauna, perhaps the most characteristic species is the gastropod *Littorina scabra* which is abundant on the leaves and trunks of mangroves.

Obviously dividing the fauna into these habitats is somewhat arbitrary and many species can occur in several habitats and they may move between habitats during a tidal cycle.

From this very brief review it is apparent that there is a very diverse fauna associated with mangroves. The fauna of tropical mangroves appears to be more diverse (total number of species) than temperate systems, although individual species may be abundant in the latter situation. Perhaps of more interest is that southern temperate mangroves lack any endemic species. In South Australia and Victoria all the marine fauna occurring in mangroves is also found on adjacent muddy shores. Around the latitude of Sydney 34° S, mangrove endemics in a wide variety of groups start appearing and increase with decreasing latitude. This parallels the increasing diversity of mangrove species with decreasing latitude.

What factors are responsible for the evolution of mangrove endemics? Is it just the larger area and continuity of mangrove stands in the tropics compared with temperate areas, or are other factors involved? I suggest that at least with regard to the marine fauna, temperate mangroves offer few advantages over adjacent bare muddy shores. Whereas in tropical areas, mangroves provide shade and protection from desiccation and far more microhabitats than the bare muddy shores where no shade is provided. Thus many species cannot survive on bare muddy shores in the tropics but they can survive in amongst seedlings and pneumatophores under a dense canopy provided by the mangrove forest. This situation has led to the evolution of mangrove endemics in the tropics, but not in the temperate regions.

What role does this diverse fauna play? Few studies to date have looked at the trophic relationships within Australian mangroves and this is urgently needed. At the moment we are relying on limited overseas data which is not good enough to substantiate the role and importance of Australian stands of mangroves especially with regard to estuarine productivity including fisheries.

References

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Collecting in a mangrove swamp — mud, sweat and polychaetes!