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THE MANGROVE ECOSYSTEM

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During the last few decades, people all over the world have begun to realize that there are many untapped unconventional resources, that could be intelligently exploited. One such natural resource along the coast in the tropics is the mangrove ecosystem.

Although mangroves occur in America, Africa and Australia, they reach the climax in South East Asia. The extent of mangroves in Sri Lanka is comparatively small. It has been estimated to be between 8000 to 10000 acres.[3] With the population expansion and industrialization, mangroves have been disappearing fast in Sri Lanka, as in other parts of the world.

Mangrove community or the mangal is a unique ecosystem. It is composed of a terrestrial, marine and a freshwater component. In a sense, this environment reflects the primitive swamp through which animals invaded land. Together with coral reefs and seagrasses, mangrove ecosystem is considered to be one of the most ancient ecosystems of the world.[16] The organisms in the mangrove community have come from the sea, land or rivers, primarily or secondarily.[14]

Mangrove flora and fauna

Mangroves interest the naturalist because of the diversity and adaptations of the mangrove organisms. Mangrove plants do not belong to the same family. Originating from different families, they show convergence in adaptations. There are 55 mangroves species in the world[8] and 28 have been reported for Sri Lanka.[1]

Although living in an aquatic environment, they live as if they are faced with **xerophytic** conditions. The salt water absorbed is desalinated within the plant by secreting salt out of the plant through special glands on the leaves. These glands are found in the leaves of *Avicennia marina* (Manda), *Acanthus ilicifolius* (Mulli) and *Aegiceras corniculatum*. Practically all the mangrove leaves have a thick cuticle for protection and reduction of transpiration.

Since the substrate on which they stand is unsteady they are supported by prop roots as seen in *Rhizophora apiculata* (Kadol) and *Rhizophora mucronata* (Kadol). Mangrove soil is acidic and poor in soil air. Thus mangroves have developed special type of roots to come above the ground in search of air. Pencil like pneumatophores found in *Avicennia* spp. and larger stumpy pneumatophores of *Sonnaratia* spp. (Kirila) is one such adaptation. *Bruguiera* spp. (Sirikanda) have developed knee roots. Since the young embryo can be easily destroyed if it falls in to this harsh environment, *Rhizophora* spp., *Bruguiera* spp. and *Ceriops tagal* have developed viviparous seeds. The seed is released from the plant at a fairly matured stage of development and the seedling can be easily fixed in the mud by the spike-like radicle. By this adaptation hazards to the young embryo is evaded.

The mangal shows zonation when the tidal fluctuation is high and when the banks have a low gradient. Zonation in the mangal of Sri Lanka is not spectacular due to the small difference in the tidal fluctuation.[20]

Mangrove animals also show diversity and adaptation. Annelids, arthropods, molluscs and chordates are the most common visible phyla living in the mangroves.

Marphysa boradellei (Kalandan panuwa) is a common polychaete in the mangroves, whose eggs are protected from the surroundings by an encasing cocoon. In the mangrove islets of Negombo, the polychaete *Branchiocapitella singularis* is common with an annual population fluctuation ranging from 10 — 60 per m^2 in the surface soil.[18] Inspite of the soil water, they migrate upwards during the rainy season.

Although oysters generally live attached to rocks, in the mangroves they are attached to mangrove roots. In the oyster *Crassostrea cucullata* (Kawati) a selection of old *Rhizophora mucronata* roots over the other species has been observed. Twenty four animal species living in association with oysters has been reported.[22]

Muddy environment is ideal for the filter feeding bivalves such as *Geloina coaxans* and *Meretrix casta* that live partially buried in the mangrove soil.

Zonation of gastropod molluscs such as *Littorina scabra*, *Cassidula musterina* and *Cerithidea cingulata* reflect their tolerance to temperature and salinity.[12]

Most of the crabs in the mangroves are not edible and belong to Grapsidae and Ocypodidae families. They live in burrows but come out for feeding. The grapsids, *Chiromantes bidens*, *Chiromantes indiarum*, *Chiromantes darwinensis*, *Neoepisesarma versicolor* and *Neosermatium malabaricum* are common in the mangroves of Sri Lanka.[19] *Neosarmatium smithii* has adapted a castle-building habit to maintain the conditions of the burrow when the mangroves are flooded during the rainy season. Among the commercially important crabs are *Scylla serrata* (Kalapu kakuluwa) and *Neptunus pelagicus* (Sinakkali). Living in close association with mangrove roots, with climbing habits is the grapsid *Metopograpsus messor*. Although not popular in Sri Lanka, the grapsid *Varuna litterata* and the portunid *Thalamita* spp. are harvested for consumption in other countries. Xanthid crabs live in association with oysters and are represented by *Baruna socialis* and *Pyseidognathus deianira* in the Negombo Lagoon. *Uca lactea* is the common species of ocypodid, while the other members also occur in the mangroves of Sri Lanka.

Different species of prawns are also found in the mangroves. Tiger prawn, *Penaeus monodon*, *Penaeus indicus* and banana prawn *Penaeus merguiensis* are commercially important species. *Acetes erythraeus* (Kunissa) and *Squill* spp. (Yakissa) also occur in the mangroves close to the sea. The snapping shrimp *Alphaeus edwardsi* is generally associated with the oysters or with mangrove roots.

Unique to the mangroves of Asia is the mud-lobster, *Thalassina anomala* that lives in a complex burrow, building mounds in the mangroves. They are active only at night and never leave the burrow.

Amphipods belonging to the genera *Lembos*, *Ceradocus* and isopods of *Cirolana*, *Ligia* and *Cyathura* genera also occur in the mangroves of Negombo.

Among the insects, two species of bees are found to frequent the mangrove plants. *Apis indica* visits the *Avicennia marina* flowers while *Apis florea* frequents *Aegiceras corniculatum* flowers. The common paddy bug *Stenocaris apicalis* and the stung bug *Glaucias dorsalis* are found on a number of species of mangrove plants. But *Oecophylla smaragdina* (Dimiyo) build their nests often on *Sonnaratia*, *Avicennia* and *Bruguiera* species.

The mangrove fish community is euryhaline, since the salinity of the mangrove water is subjected to high fluctuations. In the Negombo Lagoon the annual salinity range is from 1 to 36 ppt.[18] In Jaffna Lagoon it ranged from 15

to 50 ppt.[4] Koddiyar Bay, Trincomalee recorded a range of 7 to 34 ppt[7], and Puttalam Lagoon a range of 20 to 36 ppt.[8] Whitefield *et al*[24] have reported a salinity range of 0.7 to 112 ppt for *Elops machnata* (Mannawa) a species occurring in the mangroves of America, Africa, Asia, and Australia. *Chanos chanos* (Vekkaya) and *Therapon jarbua* (Kili) are also euryhaline with a wide range of 0.7 to 70 ppt. From a single location 128 species of fish have been reported, most of them occurring throughout the year inspite of salinity variations.[21] One of the most spectacular fish species found in the mangroves is the mud skipper *Periophthalmus* spp. (Diyahuna). Although a fish, it is adapted to a semi-terrestrial life. It can use its fins for skipping on land as well as in swimming.

The birds that frequent the mangroves have various feeding methods. Some are waders like *Ardeola grayi* (Kana koka), *Ardea purpurea* (Karawal koka), *Herodias alba* (Baddadel koka) and *H. intermedia* (Hota kalu koka). Others like *Halcyon smyrnensis* (Pilihuduwa), *Alcedo bengalensis* (Malpilihuduwa) and *Butroides javica* (Kadol koka) wait patiently for the prey while *Cheryl rudis* (Waturanduwa) and *Haliaster indus* (Rajaliya) hover over the mangroves in search of prey. *Totanus stagnatilis* (Kollila), *Totanus glareola* (Sili watuwa), *Actitis hypoleucos* (Sili watuwa) and occasionally stints are found in the mangroves, probing with their bills in the mangrove soil. The members of the above mentioned family, Scolopacinae and Laridae (gulls and terns) are migratory birds and therefore visit the mangroves seasonally. *Phalacrocorax niger* (Diyakawa) that is often found in the fresh-water tanks is also found in the mangroves. Among the birds that utilize the terrestrial component of the mangroves are the Nectariniidae (Sutikka) that come in search of nectar and Meropidae (Ambaya) that come in search of insects.

Although not confined to the mangroves, *Varanus salvator* (Kabaragoya) and *Cerberus rhychops* (Diyabariya) are also found in mangroves, predating on small animals.

The mammals that occur naturally in the mangroves are the rats and bats.

Long-term benefits of the mangrove resource

Mangroves are important because of the major role they play in the ecology of coastlands. Shore communities are one of the highly productive areas of the biosphere with a gross primary production ranging from 10,000 to 25,000 Kcal $m^{-2}yr^{-1}$ compared to less productive deserts, open sea, grasslands and continental shelf waters.[17] Estuaries and reefs are about 10 times more productive than the other coastal zones. It has been estimated that the gross primary productivity in a mangrove community to be 8 g C m^{-2} day^{-1}.[9] In primary productivity, the terrestrial component in the mangroves is as twice as that of the aquatic component.

Litterfall values of 934.4 g $m^{-2}yr^{-1}$ has been reported for the Philippines[21], 932.2 g $m^{-2}yr^{-1}$ for Thailand[2] and 967.4 g $m^{-2}yr^{-1}$ for Malaysia.[10] In a *Rhizophora apiculata* stand, Na and Ca in the leaves has been 1.67% and 1.73% respectively, while in the soil their percentages have been 7.78 and 0.04. The average N,P and K in the leaves of the same stand has been 0.89%, 0.10% and 1.01% respectively while in the soil it has been 0.52%, 0.006% and 0.182% indicating a rapid decrease in Phosphorus with decomposition.[23] 50% of the falling leaves decompose within the first month if they fall in the inter-tidal zone and 25% if they fall in the supra tidal—zone.[3]

Mangroves play an important role in the geomorphology of the coasts. They are said to reclaim land and protect from erosion. Because of their prop roots, they accelerate the process of sedimentation. Solid particles coming down the streams tend to flocculate at the river mouth due to the differences in salinities and densities and get deposited.

Mangroves are the feeding grounds of many marine fish and prawn species. (See Figure 1). Many marine fish breed off shore but their eggs and larvae drift into the mangroves to spend their juvenile stages there. The nutrients released by the decaying leaves enrich the mangrove waters. Nitrates, phosphates and silicates in the waters enhance the growth of algae, which become the food for herbivores. It has been shown that in coastal areas where mangroves occur fish and prawn catch is higher than those areas denuded of mangroves.[15]

Since mangrove community is complex and rich in species composition with diverse interspecific interactions, it is a field laboratory to study and test ecological principles. Aside from investigating theoretical hypotheses, it serves as a location for college students to visit and study nature. In certain parts of the world, mangroves are protected for their recreational and aesthetic value.

Short-term benefits of the resource

Although the contribution from the aquatic component to the productivity of the mangrove ecosystem is insignificant, compared to that of the terrestrial component, the economic benefits from the aquatic component is almost twice as that from the terrestrial component.

About 1% of the global fish production comes by way of fishing in the mangroves.[11] Aside from fish and highly priced prawns, the cockles such as *Maratrix casta* is harvested from the river bed, and *Geloina coaxans* is gathered from the forest floor for food. While poor fishermen use traditional fishing methods in the mangrove fringed lagoons, enterprising fish farmers have converted mangroves to fish ponds. In using the mangroves for aquaculture or mariculture, care should be exercised so as to leave a mangrove fringe to avoid erosion. In between such ponds, some mangrove areas should be declared as protected areas so that they continue to serve as feeding grounds for juvenile fish.

While culture of *Chanos chanos* (Vekkaya), *Mugil* spp. (Godaya), *Liza* spp. (Godaya) are already practised in the mangroves, the culture of *Siganus* spp. (Orawa), *Epinephalus* spp. (Gal kossa), *Lutjanus* spp. (Thambalaya, Ranna), *Upeneus* spp. (Nagareya) and *Lates calcarifer* (Modha) is still in the experimental stage.

Prawns and crabs are also cultured in fish ponds reclaimed from mangroves. If cage culture is attempted in the mangroves, the adverse effect of destruction of the mangrove plants can be minimised, although feeding fish with artificial food may lead to pollution of the mangroves. Oyster culture on rafts and bamboos is also tried with less adverse effects on the mangrove ecosystem.

The molluscan shells are a source of lime. Aside from oyster shells, cockle shells are also used for lime production. Lime extraction from mangrove molluscs is with no adverse effect on the mangrove ecosystem while lime extraction from corals is hazardous to the coral reef ecosystem.

Mangrove forest is extensively exploited for timber in South East Asia. 40,000 ha Matang mangrove forest in Malaysia is probably the best managed mangrove forest in the world. It has been managed for 60 years at 30 years rotation period with 3 thinnings at 15, 25 and 30 years.[10] Mangrove timber is highly priced for telegraph posts because of its strength. Since they contain a high percentage of tannins, the mangrove timber is naturally protected from insects. Fishermen also use tannins from mangrove plants to dye their nets and sails to give additional durability. Mangrove timber is also used for the production of good quality charcoal.

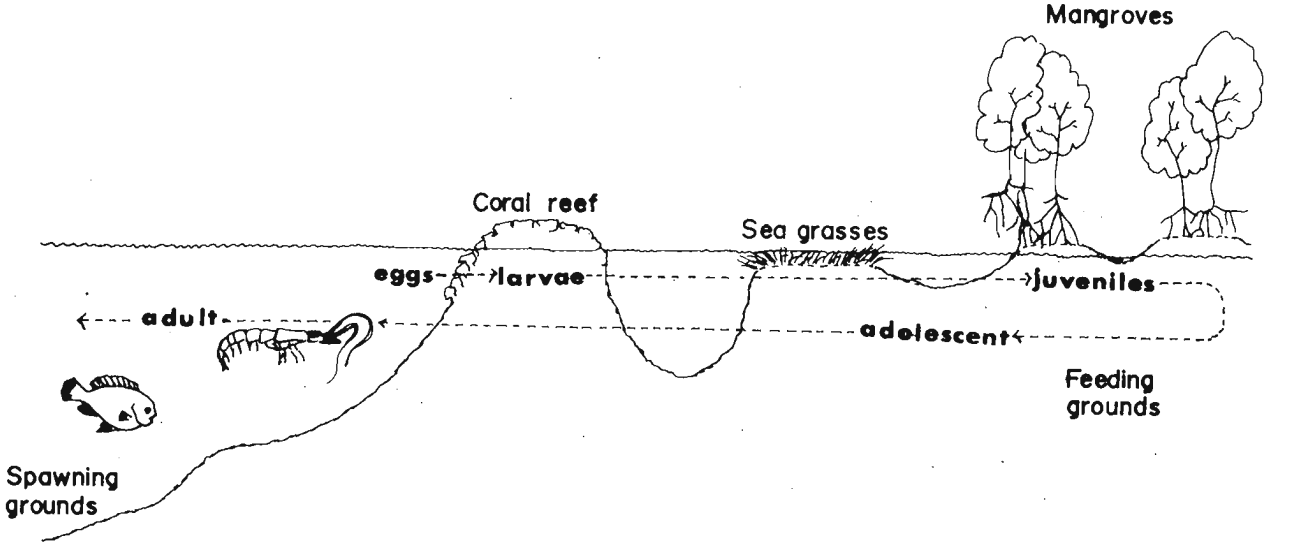
The branches of *Nypa fruticans* (Ginpol) is extensively used in South East Asia for thatching roofs and making other ornamental goods. Its flower is tapped to obtain a type of wine. The fruits of *Sonnaratia caseolaris* (Kirila) can be used to prepare a delicious fruit drink.

Bee-keeping is practised in the mangroves where *Avicennia* spp. is abundant. Even the smell of *Avicennia* spp. flowers is closer to that of honey, thus receiving the name honey mangrove.

Considering all these uses, the effects of one mode of utilization on the other can be categorized as complementary, competitive, mutually exclusive and with no effect.[5] The uses that have been discussed above fall into complementary, competitive or with no effect categories. The utilization of mangroves for human settlement, road construction, industrial and port development and agriculture excludes the use of a particular mangrove environment for other uses.

Protection of mangroves

Since this vanishing mangrove ecosystem is distributed in a number of countries and benefits a number of persons irrespective of their economic status, the world bodies have taken interest to help the world at large. UNESCO, UNEP, and WWO are some such organizations. They generally work through local agencies such as NARESA and NARA. The countries in the mangrove belt have their National Mangrove Committees. Through all these organizations, research is initiated to bring more information. This information collected by specialists is shared at regional seminars and workshops and is disseminated back to the planners and the public, thus attempting to protect this vanishing natural resource.



Utilization of mangroves as feeding grounds by marine fish and prawn juveniles.

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