Magnificent Mangroves

A Guide to the Ecology and Care of Mangroves.

by Julian Sprung

Magnificent Mangroves

A Guide to the ecology of mangroves, with husbandry requirements for the Red Mangrove, and its use in water filtration.

With this Guide I intend to provide a little natural history information about mangroves, and stimulate interest in them as an ornamental plant for marine and freshwater aquariums, and ponds.

The name "mangrove" does not refer to a specific group of related plants, but implies all salt tolerant tropical trees and shrubs that are adapted to living in or near the sea, with periodic tidal submergence of the roots or entire plant. Worldwide there are more than 50 species of mangroves. Of these, the Red Mangrove, *Rhizophora mangle*, is among the most readily recognized, with its leg-like "prop roots."

Mangroves' ability to adapt to a marine environment is managed by their capacity to conserve freshwater, and at least three salt regulatory processes: secretion, exclusion, and accumulation.

The supply of freshwater is limited in the salty soils of the intertidal zone where mangroves thrive. As a result, they have developed various ways of limiting the loss of water through their leaves. For example, the shiny surface on mangrove leaves, called a cuticle, is an adaptation to prevent water loss. On the undersides of the leaves small pores called stomata, used for exchanging carbon dioxide gas and water vapor during photosynthesis, may be constricted as a means of preventing water loss. Mangroves also vary the orientation of their leaves, pointing them upward to minimize sun exposure, and thus evaporation, during particularly harsh sunny periods.

The conservation of freshwater is essential to mangrove survival in a salty environment, but their most significant trick to adapting to the marine coastal zone is their ability to deal with the salt. Minute glands in the surface of the leaves on some mangroves allow secretion of excess salt, and rain washes the secreted salt away. Some mangroves exclude most of the salt from entering their roots by means of tissues that allow water passage but not salt, which means they are a natural sort of reverse osmosis filter! Some species of mangrove can also accumulate salt in older leaves that soon fall away with their load.

The Red Mangrove utilizes an internal "salt pump" to exclude salt (sodium) ions. Magnesium (Mg) taken from the water into the plant's cells forces out sodium (Na) ions. Therefore, when growing Red Mangroves in a saltwater aquarium one should occasionally monitor the magnesium level since the mangroves do remove some magnesium from the water. The magnesium level of full strength natural seawater (=

specific gravity of 1.025) is approximately 1300 ppm. Mangroves will tolerate a decline in magnesium of at least 25% below natural seawater values at full strength specific gravity, and tolerate even greater depletion of magnesium at lower specific gravity. When magnesium is depleted in the water, mangroves exhibit signs of salt stress, such as shriveling of the leaves and branches, or yellowing of all the leaves. Mangroves grown in freshwater do not require so much magnesium because they don't have to exclude sodium ions.

Mangroves grown in aquariums do not require fertilizers (nitrogen or phosphorus) since the fish food and waste supplies these nutrients. Fish foods also supply other important plant nutrients such as potassium, iron and manganese, but it may be beneficial to add these elements weekly to the water in the form of a commercially available trace element supplement, particularly when using the mangroves in large quantity to filter the water.

Mangroves commonly grow in waterlogged, anaerobic soil, mud, or sand. They may also take root in limestone rock or on top of coral heads. Their roots in anaerobic soils do not extend very deep, but spread out laterally instead to provide a secure footing in the loose substrate. These so-called "cable roots" may produce special finger-like upwardly projecting breathing structures called pneumatophores or "snorkel roots" that are filled with spongy tissue. Numerous small holes on their surface allow oxygen to be taken in and transferred to the below-ground cable root

Prop roots of the Red Mangrove.

Black Mangrove Snorkel Roots (pneumatophores).

system. The oxygen supplied to the roots in anaerobic soils is vital for growth and nutrient uptake. Snorkel type pneumatophores are typical for the Black mangroves, *Avicennia* spp, while other species may have knee, ribbon, or plank shaped forms.

The Red Mangrove is distinguished by aerial "prop roots" that extend from its branches, trunk, or other aerial roots. These give the impression that the tree could get up and walk like a spider. Aerial roots also take in oxygen, and they provide firm anchoring where they contact the substrate.

Mangroves all possess to varying degrees a unique form of reproduction called vivipary, in which "live birth" of seedlings occurs; the seeds geminate while still on the tree. These advanced seedlings are known as propagules. Mangrove propagules are specially adapted for dispersal by water. They come in a variety of shapes and sizes, some like long rods, some like balls, and others like cigars or beans. They are buoyant and can drift for months before taking root in a suitable substrate. Many are lost by washing up high on a sandy beach and drying out in the sun. Long, cigar shaped propagules such as those of the Red Mangrove, *Rhizophora mangle*, float upright in the water, roots trailing below and leaves sprouting above.

When I tell aquarists that mangroves grow perfectly well in freshwater they typically respond with amazement and disbelief, stating that they thought mangroves required saltwater to grow. It would seem that the Red Mangrove might require some salt as it is not found too far from salt water in its natural habitat. Nevertheless, I have found some Red Mangroves growing naturally in freshwater in canals and rivers that lead to saltwater bays. In the southern part of the Florida Everglades and along the gulf coast of Florida they grow in freshwater, but there is a limit to how far they naturally occur from the sea, and I'm not really sure why. Perhaps it is intolerance to drying out, cooler winter temperature further inland, or simply the direction of water flow from land to sea. In aquariums the limiting factor doesn't exist; they can be grown perfectly well in pure freshwater, even soft water. They are quite hardy and adaptable!

About the only limitation to keeping mangroves in aquariums is their need for enough room to grow upward. This means that a closed canopy should be avoided, generally. I have seen aquariums with canopies and mangroves where the trees were allowed to grow out the back, receiving light from a nearby window. One might reasonably ask how, even with an open aquarium , the mangrove can be prevented from growing too tall. If one prunes the mangrove in the manner recommended for Bonsai tree cultivation, the leaves do become smaller, new branches develop, and a miniature tree can be created. In a tall aquarium with a lid it is possible to house such miniaturized trees, and in an open aquarium such pruning prevents the trees from growing too close to the light source.

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Red Mangrove propagules still attached to the tree.

After the bud in the center was cut, two new branches grew.

One must provide a source of light sufficient to meet their needs and a humid environment. A single fluorescent lamp can be sufficient if it is close enough to the leaves, but it is best to have two or more tubes when using fluorescent light. A pendant metal halide lamp works well for growing them. If the leaves are too close to the light source they will turn yellow and dry up. Be sure to allow at least four inches between the bulb and leaves. Light from a window is also sufficient, and it is possible to set up a small aquarium in your window with mangroves...kind of different from the typical potted house plants. I found that in really dry climate, or in winter when the air indoors tends to by drier, the mangroves seem to require daily misting to keep the leaves from drying up. Under most circumstances, however, misting is not required more than occasionally to wash off salt or dust.

Temperature is another important factor in aquariums and in nature. Mangroves thrive in the tropics, though some species extend into temperate regions. Generally they do not tolerate freezing temperatures. In north Florida along the gulf coast whole islands of Red Mangrove forest were wiped out by a severe cold front in the late 1980's. The more cold tolerant Black mangrove, *Avicennia*, was not affected. Sporadic survivors and new recruits have since filled in the gaps, but for years the islands looked like a pile of bones as the dead mangrove trees bleached in the sun and the guano from seabirds coated them white. If you plan to grow mangroves in a pond or outdoor aquarium, they must not be exposed to cold weather. They do tolerate very warm weather (and water) however, so summertime outdoors presents no problem, aside from the need to keep up with evaporation that could leave the trees parched.

I have encountered two problems with growing Red mangroves that are frustrating but manageable: bugs and shock. Insect pests can be a problem with mangroves and any other aquatic plant that grows leaves out of the water. Mealy bugs, scales, white flies,

and mites are damaging pests that can be difficult to control, particularly when you can't use pesticides because the plants are housed in a fish tank! There are predatory insects that prey upon and control these pests in a greenhouse culture situation, and they are obtainable from organic gardening suppliers. In general, however, I control insects affecting mangroves housed in an aquarium by hand. I check the leaves and smoosh and wipe off any insects. Farm-raised hydroponically grown mangrove seedlings are insect and pest free, but house plants and fruits from the grocery store (particularly bananas) often bring mealy bugs or white flies into the home.

Mangroves can suffer "shock" when they are moved. This is manifest by wilting leaves or loss of leaves. When the leaves wilt or drop off in a moved plant, I place it in tap water and give it strong illumination. Usually the tree recovers within a few days. If the leaves have all dropped off, the top bud will usually open within 10 days if the tree is placed in tap water and given strong illumination. When adapting a mangrove from freshwater to saltwater it is important to make the transition slowly; otherwise the plant can suffer irreversible shock. First expose the plant to slightly brackish water and allow the water to become saltier over several days time. It is also important to be sure that the magnesium level of the saltwater is sufficient; see my earlier explanation regarding magnesium and its effect on salt tolerance.

Brackish aquariums can also house mangroves. It is possible to create the natural habitat of the amusing mudskipper fish by incorporating mangroves, sand, and a shallow water level. I remember as a child reading about these frog-like fish in a National Geographic magazine that had a photo on the front featuring one out of water adhering to a mangrove. I have seen these biotopes created in numerous public aquariums, sometimes with fake mangroves, but more recently I have seen exhibits done with the real trees and mudskippers. One exhibit I saw at Hagenbecks Tierpark in Hamburg Germany also housed the four-eyed livebearing fish *Anableps anableps*, and since the water level was shallow, they could be viewed from the front, below the water level and above it. This exhibit also featured a tidal change, evidenced by water marks on the glass. With tidal change it would be possible to house some of the nerite and littorinid snails that graze algae off the Mangrove's roots, and possibly *Sesarma* crabs, or *Uca* species a.k.a. "Fiddler crabs." Another brackish water fish that occurs with mangroves is *Toxotes jaculatrix*, the Archerfish, famed for its spitting ability. With these three very strange fish and the unique mangrove tree one can make a rather special aquarium in brackish water. Other public displays I have seen that feature mangroves include Biosphere 2 in Oracle, AZ, the Löbbecke Museum in Dusseldorf Germany, and the Waikiki Aquarium in Honolulu. New displays of mangroves are also at the Florida Aquarium in Tampa, Florida and the Museum of Science and Discovery in Ft. Lauderdale. The Aquarium in the Oceanographic Museum in Monaco has a display of Japanese mangroves

The brackish water Archer Fish lives in the Western Pacific region among the roots of mangroves, where it hunts insects.

behind the scenes, and may soon develop a public exhibit for them.

In a marine tank these trees can be used to create a whole aquascape or just an accent. In my reef aquarium I plant mangroves on the upper rocks, holding them there with plastic toothpicks or rubber bands until the roots grow into the rocks and anchor the trees in place. I do have to trim the branches occasionally, and sometimes prune stray roots. Corals and anemones soon grow onto the stalk of the tree, a stunning effect when viewed from above. To speed up this process, one can tie zoanthid anemone polyps to the stalk with monofilament (fishing) line or use cyanoacrylate adhesive to attach the polyps.

Common questions about the care & use of Red Mangroves in aquariums:

Q. How do I plant the mangrove in my aquarium? Does it need soil or is sand or gravel OK?

A. Depending on the aquascape, size and depth of the aquarium, available substrate, and whether the aquarium has an open top, there are several correct ways to plant a mangrove in your tank. Regarding substrate, mangroves do not require soil or substrate of any kind to grow. They grow perfectly well with bare roots in water. For aesthetic reasons in a display aquarium one should plant mangroves on the tops of rocks or in the bottom substrate (sand or gravel).

Q. How many mangroves per gallon should I use if I want to realize their benefit for water filtration?

A. Despite claims to the contrary, one or two mangroves will have no noticeable

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An outdoor marine aquarium with mangroves and fish.

An indoor reef aquarium with mangroves and corals.

affect on water chemistry parameters such as the nitrate and phosphate level, even in a small aquarium. Mangroves remove these nutrients from the water more slowly than faster growing algae do. Nevertheless, it is possible and quite interesting to set up an effective mangrove filter system employing a small "forest" of mangroves. For small aquariums (10 to 30 gallons) a quantity of approximately one mangrove per gallon placed in an illuminated filter chamber attached to the aquarium will work well as a nitrate and phosphate filter. For larger aquariums (50 to 200 gallons) a quantity of one mangrove per two gallons may be sufficient. If you are patient and have the room to grow them, a much smaller quantity of older, larger trees will also function well in an attached mangrove filter tank.

Q. How can I build and maintain a mangrove filter?

A. A mangrove filter can simply be a 10 or 20 gallon tank or tub plumbed to be connected to the water circulation of the aquarium. One may use a Jaubert style plenum system with a thick gravel bed, or sand or gravel directly on the bottom, a Leng Sy mud bottom, or simply leave the plants bare-rooted, hydroponic style. These mangrove plant reactors or mangrove filters can be located in the cabinet below the aquarium or adjacent to the aquarium. Of course they require a source of illumination. A mangrove filter placed next to a window with good sun exposure may not require any supplemental lighting at all.

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Q. Will the mangroves turn my water brown?

A. Some aquarists who have seen mangrove ecosystems in the wild have noted the typically brownish water that is commonly associated with mangroves in relatively enclosed embayments. This color is caused by tannins released by decomposing leaves. If the aquarist does not allow the leaves to drop into the water and decompose, the color of the water will not be significantly affected by the presence of mangroves in the system. The normal use of activated carbon will prevent the water from becoming yellow, as in any closed system aquarium.

Although impractical for most clean, nutrient poor display aquariums, allowing the leaves to decompose in the water can make for an extremely interesting saltwater pond aquarium that duplicates the complex food webs associated with mangrove ecosystems. Bacteria, fungi, other microorganisms and crustacea decompose the leaves produce a rich environment full of life. A brightly illuminated mature aquarium of this sort could house Pygmy Seahorses, Dragonettes like the Psychedelic Mandarin, Killifish, Mollies and other fishes, without the need for supplemental feeding. The not yet published book *The Reef Aquarium* Volume Three will explain in detail how to create such self sustaining habitats. Additional information about building such systems can be found in Adey and Loveland's book *Dynamic Aquaria: Building Living Ecosystems*.

Q. The leaves dropped off my seedling. What should I do?

A. When first acclimated to an aquarium it is common for mangroves to drop one or more leaves. The unopened leaf bud will unfurl to produce two new leaves and another bud or two within a couple of weeks. Before the mangrove is securely rooted in place, it is common for the pair of leaves below the bud to drop off as soon as new leaves open from the bud.

Q. How do I prune the mangrove?

A. Using a sharp pointed scissors, cut the unopened leaf bud right at its base above a pair of leaves (see photo). Stray branches on larger trees may also be cut with a sharp scissors or clipping shears. Leaves may be cut or snapped off. Do not cut more than a couple of leaves per day on small mangroves.

Q. Can I or should I cut the roots?

A. It is not a requirement to trim the roots at any time, but one may use a scissors to trim a root that has grown into an area of the aquarium where it is aesthetically not pleasing. Older mangroves produce a dense peat-like tangled mat of fine roots. These can be trimmed back occasionally, if necessary. DO NOT CUT OR DAMAGE

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THE ROOTS OF SEEDLINGS AS THIS CAN INJURE THEM SEVERELY.

The Importance of Mangrove Ecosystems

Mangrove ecosystems, known as "mangals," are important nursery grounds for numerous fish and invertebrate species, including commercially valuable shrimps, crabs, lobsters, groupers, snappers, and mackerel. Many smaller, non-commercial species spend their juvenile stages in the mangals and later migrate to the open ocean, where they are an important food source for larger commercially valuable fish. Some crabs and shrimps that spend most of their adult lives in the mangroves migrate to the open sea to spawn. Many species of algae can be found growing on and near the roots of mangroves. Sponges, oysters, barnacles, corals, bryozoans, tunicates and other invertebrates also make the submerged mangrove roots their home. Other creatures associated with mangrove ecosystems include Sea Turtles, Crocodiles, Manatees, and Dugongs. In addition to aquatic organisms, terrestrial animals including deer, raccoons, snakes and birds utilize the mangrove habitat as their home and hunting grounds.

Mangroves and adjacent seagrass beds and coral reefs are linked by the water masses that exchange between them with the tide, and by the animals and plants that move with the water between these habitats. The water flow link also is important for the transport of nutrients between these different coastal habitats, though the importance of the nutrient exchange between the habitats depends on their proximity.

People living in tropical coastal zones have long utilized mangroves for a variety of purposes. In addition to the use of the habitat for fishing, various products from the trees are valuable resources. The propagules of some species in the southwest Pacific, for example, are eaten. Some people use the bark as a source of tannins or dye, and the wood to build durable and water resistant houses, boats, pilings, or furniture. Black mangrove wood and the wood from the closely related Buttonwood tree is used to produce charcoal. Even the leaves are used, in teas, medicines, food for livestock, or smoked like tobacco, and the flowers are in some localities important for bee farmers in the honey industry. Utilization of the renewable natural resources of mangals in general enhances their perceived value to the people who use them. It is also well recognized by people living in coastal regions that mangroves are a flexible soft buffer to the waves generated by tropical storms. They therefore provide protection for the adjacent terrestrial environment. It is an unfortunate fact that in many places mangals are not protected from coastal development and construction projects that destroy them to build houses, farms, roads, airports, and golf courses. As a result, large tracts of habitat have been lost, mostly in the past century.

Now that you've purchased a farm-raised Red Mangrove seedling and this guide, I know that you too will enjoy the beauty of these unique "walking trees" in your aquarium, pond, tropical plant garden, or windowsill. I encourage you to learn more about mangroves and their important natural habitat by reading the literature I've included here in the "suggested readings." I hope that your appreciation of these trees and their habitat will encourage you to educate other people about the need to protect mangrove habitats from land

The beautiful little flowers of the Red Mangrove. In some regions mangrove flowers are important to honey producers.

development and other activities that destroy them.

Suggested Readings

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