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Mangrove Fauna and Their Adaptations in the Kota Kinabalu Wetlands

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INTRODUCTION

'Mangrove swamps' are often mistaken as being synonymous to 'wetlands' due to their extensive transition between land and sea. Mangroves are often used by people for sustainable purposes, as well as for more alarming publicity for their conservation compared to other wetlands. The Ramsar Convention recognizes 42 types of wetlands; mangrove swamp is only one of them. The Convention's definition of wetlands is "areas of marsh, fen, peatlands or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres" and "karst system wetlands" (Ministry of Natural Resource and Environment, 2005).

Mangroves are home to many molluscs, crustaceans, insects, fish, reptiles, amphibians, birds, mammals and microscopic creatures that have adapted to life in the muddy and brackish environment which makes up the complex ecosystem characterizing mangrove forests. These species interact in myriad ways, with complex interdependencies, patterns of predation, parasitism and commensalism (Spalding, Kainuma and Collins, 2010). These interactions form mangrove food webs and play a critical role in nutrient cycling.

The physical structure of mangroves is the basis which drives these ecological interactions. The complex and solid structures of roots provide habitat and shelter for many molluscs, crustaceans and fish. The upper parts (branches and tree crowns) of mangroves which are not normally inundated by tidal water are home to many terrestrial animals such as insects and reptiles. Birds, including species that feed in adjacent ecosystems, use mangroves as nesting and roosting grounds. The degree to which animals depend on mangrove environment is highly variable; while some are only found in the mangrove environment, others are opportunists that may benefit

from mangroves but live elsewhere. Also, some marine species use mangroves for just part of their life cycle—for breeding and as a nursery.

THE MANGROVE ENVIRONMENT

Kota Kinabalu Wetlands is a 24-hectare brackish water mangrove swamp in the heart of Kota Kinabalu City which experiences diurnal tidal changes every day. A recent study (Williams, 2011) showed that the tidal changes at Kota Kinabalu Wetlands are 1–2 hours later than those stated in Sabah Marine Department's tidal table for Kota Kinabalu. Freshwater enters the mangrove forest in Kota Kinabalu Wetlands mainly via a canal which is also connected to a short concrete drain from the nearby residential area and a canal originating from a manmade pond. Runoffs from Kota Kinabalu Wetlands flow downstream into Likas Bay and finally to the South China Sea via this canal, which is also the only source for the mangrove's seawater intake.

As the water channels located upstream and downstream of Kota Kinabalu Wetlands are concrete drains, the biological distribution in this remaining patch of the mangroves that once existed along the coast of Kota Kinabalu City is minimized. Aquatic organisms such as fish, jellyfish and horseshoe crabs easily swim to and from the Kota Kinabalu Wetlands from the sea; however, molluscs and crustaceans are separated from those found at nearby mudflats.

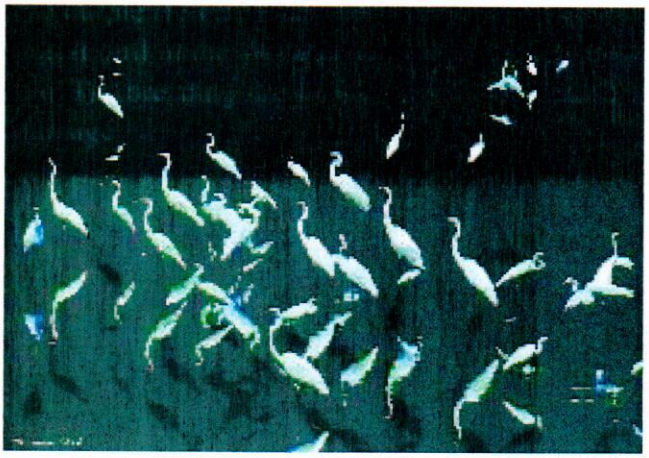
FAUNA

More than 90 species of migratory and resident birds, 20 fish species, 14 crustacean species, 13 mollusc species, 9 insect species and 5 reptile species have been recorded in Kota Kinabalu Wetlands. In 2009 the Sabah Wetlands Conservation Society (SWCS) recorded 84 bird species, and an additional 8 species have been recorded since then. The abundance of food sources in the mangroves due to its function as nursery grounds for many marine animals is the reason why the mangrove canopy is home to numerous bird species.

The mangrove swamp offers habitats for resting and feeding for migratory birds, usually sighted from September till April. In August 2011, Common Kingfisher (*Alcedo atthis*) and Common Sandpiper (*Actitis hypoleucos*) were seen feeding within the Wetlands; these appear to be some of the earliest migrants from the northern hemisphere. Almost all year round the most common waterbirds are the egrets and herons.

Egrets, the most commonly seen birds at the Wetlands, can be easily sighted early in the morning and late afternoon. The three egret species are the Little Egret (*Egretta garzetta*), Intermediate Egret (*Egretta intermedia*) and Great Egret (*Ardea alba*).

The Purple Heron (*Ardea purpurea*) is a mascot for Kota Kinabalu Wetlands. It is the largest bird in the Wetlands, measuring up to 90 cm tall; it nests amidst a blanket of fern. The breeding season is around April to June. Juveniles look darker with chestnut plumage.



Top Left: Egrets hunting for food.
Top Right: Purple Heron, the largest bird in Kota Kinabalu Wetlands.

The mangrove swamp is a haven for an abundance of aquatic organisms. Fiddler crabs (*Uca* spp.) are small and colourful. The male has distinctively asymmetric pincers; the larger pincer is used in the courtship battle over females. The Archer Fish (*Toxotes jaculator*) typically inhabits brackish water, but can also be found in the open ocean and in freshwater. Mudskippers (*Periophthalmus* spp.), which inhabit the mangrove environment, can walk on land. They are categorised as fish due to their functional gills, as present in any other fish.

Like migratory birds, horseshoe crabs (*Carcinoscopius rotundicauda*) are seasonal visitors to Kota Kinabalu Wetlands. They are often seen swimming in pairs with the male clinging onto the back of a female, searching for the best site for spawning. Horseshoe crabs do not have haemoglobin in their blood, but instead use hemocyanin to carry oxygen. Because of the copper present in hemocyanin, their blood is blue. Their blood is collected for pharmaceutical and medical purposes such as endotoxin tests to ensure that medical products are free from bacterial contamination.

Reptilians like the Mangrove Skink (*Emoia atrocostata*) and Dog-faced Snake (*Cerberus rynchops*) are often avoided by humans due to their eerie appearance. However, these carnivores play important roles in mangrove food chains which embody the natural balance of the mangrove ecosystem.

Certain animals are often viewed by humans as insignificant due to their small size or microscopic character. Nine insect species have been recorded at Kota Kinabalu Wetlands. Insects contribute both advantages and disadvantages to the mangrove

ecosystem. They are valuable scavengers, pollinators and predators as well as a source of food for birds, fish and other animals. However, many are regarded as pests; often, all that can be seen is the damage they have caused. For instance, the characteristic silvery mines on the upper surface of the mangrove leaf are caused by leaf miner moths (*Phyllocnistis* spp.), and circular grazed patches on the leaves of *Avicennia* are caused by Avicennia leaf beetles (*Monolepta* spp.).

Many people think that mangroves are dirty and smelly and, therefore, 'wastelands' which are cleared to make ways for buildings or used as dumping grounds. In the 1980s Kota Kinabalu Wetlands was badly degraded due to the presence of illegal settlements constructed within the mangrove swamp. Senior staff of Kota Kinabalu Wetlands lament that otters and Long-tailed Macaques (*Macaca fascicularis*) which once wandered the mangrove swamp are no longer sighted. Birds such as the Straw-headed Bulbul (*Pycnonotus zeylanicus*) and the Black-shouldered Kite (*Elanus axillaris*) have disappeared from the Wetlands ever since the boundary of the area they perched on was developed as a golf course.

When the mangrove swamp was gazetted for protection in 1996, mangrove replanting to restore the badly degraded mangroves was the priority. It was a success, as is evident now with most of the area covered with lush mangroves. However, being located at the urban area it is easily accessible and became a poaching site for clams and fish. Development in the surrounding area has brought added pressure to this remaining patch of a once extensive mangrove forest. If human activities, whether directly or indirectly related to the mangroves of Kota Kinabalu Wetlands are unsustainably managed, this mangrove patch which houses myriad flora and fauna that depend on intertidal zones, correct temperature, availability of freshwater and seawater, as well as food, can easily become isolated and malfunction.

FAUNAL ADAPTATIONS

Structure

Fauna found in the mangrove are very diverse as they come from both sea and land environments. The marine fauna found in mangroves around the world are broadly similar; this is not surprising as dominant animals, such as the soft-bodied often hard-shelled molluscs and the segmented-bodied, jointed-limbed and hard-shelled crustaceans, have sea-borne larval stages and are distributed by the currents (Field, 1995). The tidal cycle exercises a profound influence over the behaviour and activity of the marine animals in the mangroves. Large mangrove animals living on the surface of the mud, which is exposed at low tide, are almost always protected from drying out by a shell or some hard supporting structure (Field, 1995).

Behaviour

During low tide at Kota Kinabalu Wetlands the edible Giant Mud Crab (*Scylla serrata*) burrows itself motionless in the mud to avoid the hot, and drying, surface of the exposed mud. As it looks very much like mangrove mud, it is hardly spotted by predators. Smaller crabs such as fiddler crabs (*Uca* spp.), sentinel crabs (*Macrophthalmus* spp.), and sesarmine crabs (*Sesarma* spp. and *Nanosesarma* spp.) tend to shelter between the roots and pneumatophores of mangroves, and the stands of boardwalk.

Most of the mangrove animals prefer to live out of water. Even the fiddler and sesarmine crabs are burrowers; during high tide they maintain a bubble of air underground and use the tufts of hair at the base of their legs and/or on the face to absorb water into their gill chamber through capillary action (Ng et al., 2002). Another burrower, the Mud Lobster (*Thalassina anomala*), is a nocturnal crustacean that feeds on organic matter in the mud. It builds a long-tunnel burrow by excavating the mud to the surface, forming volcano-like mounds. This activity can shift vast quantities of mud, and hence contributes to the recycling of nutrients in the ecosystem. While some crustaceans are sealed in their burrows, the tree-climbing crabs (*Episersama* spp.) are seen motionless on the mangrove trees during high tide to escape from predators like fish, kingfishers and monitor lizards.

Molluscs at Kota Kinabalu Wetlands comprise bivalves and gastropods. They are scattered on the mud or attached to the leaves, stems and roots of mangroves. One bivalve, Lokan (*Polymesoda expansa*), is well adapted to the mangrove habitat as it is able to tolerate long periods of low tide by burying just beneath the mud; it rapidly resumes filter-feeding when inundated. Gastropods such as mangrove periwinkles (*Littoraria* spp.) and the Common Nerite (*Nerita lineata*) are mostly found on the leaves and stems of mangrove trees. Mangrove periwinkles graze on the leaf hairs and epilithic algae, while the Common Nerite grazes on algae at night during low tide to avoid predation from crabs and fish.

To hunt for food in the mangroves, the Archer Fish (*Toxotes jaculator*) prefers to leap out of the water to grab the prey in its jaws. When the leap fails, it may then resort to a 'shooting' action. Often, several fishes shoot water relentlessly at the same prey until it finally falls into the water; then all rush to grab it. The Halfbeak (*Hemiramphus* sp.), a slender skinny fish with a long beak found in the mangroves, also prefers hunting for insects. However, instead of a shooting action, they swim along the surface of the water waiting to eat small insects like ants.

Birds like the Little Heron (*Butorides striatus*) are often seen standing on the stilt roots of mangrove trees hunting for fish. They sometimes use bait, dropping a feather or leaf gently on the water surface to attract fish.

Physiology

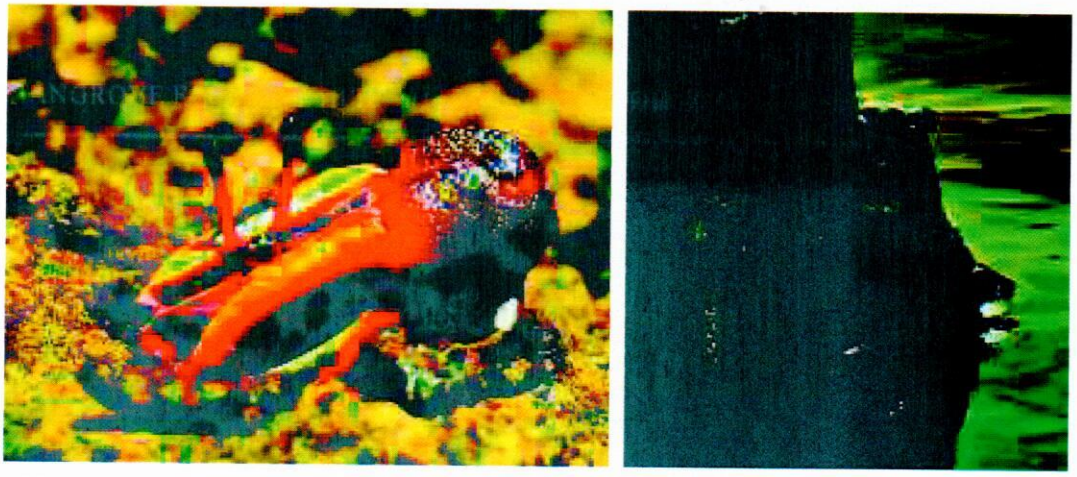
The colourful fiddler crab has the ability to change its colouration from pale at night to dark by day. Why it does this is still a mystery; it is possibly for camouflage or to protect it from the sun's rays.

Mudskippers (*Periophthalmus* spp.) are also well adapted to life in the muddy mangroves. Bestowed with strong pectoral fins and enlarged gill chambers that can lock to retain water, mudskippers are able to absorb gaseous oxygen through their blood-rich membranes at the back of the mouth and throat; their skin is rich with blood capillaries. Mudskippers linger and skip on land during high tide, but often with their tail in the water to keep the body moist. Their 360 degree-view eyes with moveable eyelids make the fish difficult to prey on.

The Little Egret (*Egretta garzetta*) has yellow feet, which are an advantage when hunting for food. It waves its bright foot in the shallow water to attract fish and crustaceans before dashing about to chase them.

In an environment that is extremely low in oxygen with natural occurrence of sulphide, microbes in the mangrove soils are those that can adapt to these harsh conditions. They help to decompose organic matters such as fallen leaves and dead animals in the mangrove. The 'rotten egg' smell of mud is the hydrogen sulphide released due to the anaerobic bacteria activity in the soil. The tides then remove the hydrogen sulphide build-up in the soil as a high concentration is toxic to the living organisms in the mangroves.

Top Left: Oysters (*Isognomon ephippium*) are hard-shelled bivalves.
Top Right: Tree-climbing crab (*Episersama* sp.) clinging on the mangrove during high tide.



Top Left: Fiddler crab (*Uca* sp.) changes its colouration from pale at night to dark by day. Top Right: Mudskippers (*Periophthalmus* sp.) keep their body moist on land.

CONCLUSION

Kota Kinabalu Wetlands has wide faunal species diversity despite its small area of mangrove swamps. These fauna are categorised into seven major groups: birds, fish, crustaceans, molluscs, insects, reptiles and microbes. They are bestowed with amazing skills to manipulate their biological systems to enable them to survive the harsh conditions of the mangrove environment. These adaptation skills can be in the form of structure, behaviour or physiology. Humans have imitated many of these functions in science and technology. Although these animals have the ability to cope with the harsh conditions, human activities such as rapid development in the vicinity have increased the stress to the ecosystem. Hence, by understanding the biology of animals and their relationship with humans, we can make wise decisions that would sustainably benefit all.

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