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Species composition and stand structure of an exploited mangrove forest

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Abstract

A study was conducted in a disturbed mangrove forest that had been gazetted as a national park in Sarawak, Malaysia. This study provides information regarding the status of disturbed mangroves and can be used as baseline data to support decision making in managing mangrove forests. The objectives of this study were to determine the tree species composition and structure of an exploited mangrove forest. This study was carried out in Kuching Wetland National Park (KWNP). Eight transects were established and in each transect sampling plots of 20 x 20m were established. All standing trees with a diameter at breast height (DBH) ≥ 5 cm within each plot were enumerated. Generally there are three major forest types in KNWP: mixed-mangrove forests, *Sonneratia alba* forest and heath or kerangas forest; a total of 98 species were recorded. *Sonneratia alba* forest dominates the sandy mudflats. However, their occurrence is not extensive, being confined to areas along the rivers, coastlines and estuaries of Batang Salak opposite Pulau Salak. The forest occurs on the seaward fringe as a narrow strip about 20 – 30 meters wide. The vast majority of the mangrove area can be classified as mixed-mangrove forest composed of *Rhizophora apiculata* and *Rhizophora mucronta* interspersed with *Xylocarpus granatum*, *Avicennia alba* and *Nypa fructicans*. More than 60% of the mangroves are pole size with a DBH between 5 and 10 cm. *Avicennia alba* recorded the highest basal area with 4.5 m^2/ha followed by *Rhizophora apiculata* (3.8 m^2/ha) and *Avicennia marina* (1.3 m^2/ha). Some areas in KNWP are made up of heath forests scattered throughout the interior of the park. The heath forest has a uniform single-layered canopy with trees reaching up to 22 m in height. There are no mangrove species in the heath forest and the common trees are *Syzygium ochneocarpa*, *Whiteodendron moultonianum* and *Casuarina sumatrana*. In general, the species composition in KNWP is rich and the regeneration status is good.

Key words: Mangroves, Kuching Wetland National Park, Stand structure, Species composition, Heath forest

Introduction

The total area of mangrove forest in Sarawak is approximately 127,736 ha, which is about 1% of the total area of Sarawak (Abg Ahmad *et al*. 2008). The majority, about 80% of the state's mangrove forest, is found in the Kuching and Mukah Divisions. Another 5% is found in the Limbang Division. The remaining 15% of forest areas are located in Sri Aman, Sibu and Miri. In Sarawak, the management of mangrove forest began in the 1920's and the main objective was to sustain the production of mangrove-related products (Abg. Ahmad 2008).

The area now making up the current Kuching Wetland National Park was exploited by licensed contractors prior to its incorporation as a national park. After the creation of KWNP in 2002 and the Ramsar site in 2005, extraction for mangrove poles continued. However, after the establishment of KWNP, the license to extract mangroves was only given to locals living in the vicinity of the national park. For the area to continue providing ecological and commercial benefits mangrove forests must remain intact with minimal or no disturbance. The park provides protection of the coastline, various villages, farms and some areas of Kuching from erosion, salt intrusion, storm damage, flooding and siltation. Rapid development in the surrounding area will certainly have an impact on the park vegetation due to the increasing clearing of mangroves for agricultural activities, tourism, housing and urbanization. Nevertheless, information

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regarding the park vegetation impacted by the continued mangrove extraction is scarce. Comprehensive species-specific data is important for implementing conservation initiatives including regulation of resource extraction and clearing (Polidoro *et al*., 2010). The objectives of this study were to determine tree species composition and structure of an exploited mangrove forest. The data can serve as a baseline in managing the park.

Materials and Methods

Sampling

The study was carried out using eight transects. Along each transect, sampling plots of 20 x 20 m were established. Except for the heath forest, the survey area experiences daily tides and the soil is somewhat water-logged. The area is relatively flat with occasional low and small mud mounds. In each plot, all standing trees with a diameter at breast height (dbh) ≥ 5 cm within each plot were enumerated. The tree diameter at breast height (i.e. 1.30 m above ground level) was measured over bark to the nearest cm. Enumerated trees were identified up to the species level. The identification was based on bark, slash and leaf characteristics. However, if the species of the tree could not be identified, it was sufficient to identify the plant up to genus level. Trees with a diameter of five cm and below were classed as saplings and were recorded. Tree diameters at breast height were measured over bark to the nearest cm using a diameter tape. Total tree heights were estimated using Suunto Clinometer.

Results and Discussion

Forest Type

Generally there are three major forest types in KNWP: mixed-mangrove forests, *Sonneratia alba* (perepat) forest and heath or kerangas forest. Many of the forest subtypes classified by Chai (1975) were observed in KNWP, however, the distinctive features were not obvious due to the continuous extraction of mangroves. *Sonneratia alba* (Perepat) forest dominated the sandy mudflats. However, their occurrence is not extensive, being confined to areas along the rivers, coastlines and estuaries of Batang Salak opposite Pulau Salak. The mangrove area occurs on the seaward fringe as a narrow strip about 20 – 30 meters wide. This species colonizes newly formed silty mudflats and is seen as a pure stand. *Sonneratia alba* trees are the host trees of fireflies (*Pteroptyx tener*) and flashing is evident at dusk. The leaves of *Sonneratia alba* is the main source of food for the proboscis monkey (*Nasalis larvatus*) of Borneo (Salter *et al*. 1985). The presence of the proboscis monkey is very noticeable with single monkeys or groups of three or four monkeys being present during daytime hours and consuming *Sonneratia alba* leaves. *Sonneratia* leaves contain high levels of protein, phosphorus and potassium (Yeager *et al*., 1997).

The majority of the mangrove area is classified as being made up of mixed-mangrove species. This area is composed of *Rhizophora apiculata* (Bakau minyak) and *Rhizophora mucronta* (Bakau kurap) interspersed with *Xylocarpus granatum*, *Avicennia alba* and *Nypa fruticans*. Young *Rhizophora apiculata* stands dominate the river, tributaries and channel banks. The ground, which is usually silty and composed of sandy-loam soil, is totally covered by dense, interlocking and tangled stilt roots. Bakau minyak regenerates very well (Chai 1982). Old *Rhizophora apiculata* trees are found on higher ground. The trees are straight and pole-like, and most of the pole-size (4 – 10 cm) trees in KNWP have been extracted for commercial use. *Rhizophora mucronta* is generally found to be less extensive than *Rhizophora apiculata*. In KNWP, *Rhizophora apiculata* is associated with *Avicennia alba*, *Xylocarpus granatum*, *Nypa fructicans*, *Bruguiera sexangula*, *Bruguiera gymnorrhiza*, *Kandelia candel*. The associated species vary according to soil type, estuarine upstream location, and tidal position. In frontal stands, young *Rhizophora apiculata* mangroves may be associated with *Avicennia alba* and *Nypa fructicans*. The occurrence of *Xylocarpus granatum* in drier ground is associated with *Bruguiera* spp. and older *Rhizophora apiculata*. On the landward sites where the ground is much drier, mixtures of *Lumnitzera* spp., *Excoecaria agallocha*, *Kandelia candel* and *Xylocarpus granatum* are common.

Some areas in KNWP are made up of heath forests scattered throughout the interior of the park (Fig. 2). The heath forest occurs on higher and drier ground of about 5-6 m a.s.l. and receives no tidal inundation. These forests are extremely different from the mangrove forest in structure and species composition and they have a uniform single-layered canopy with trees reaching up to 22 m in height.

Species composition

A total of 98 species were recorded in the KNWP (Table 1). Of that total, about 36% or 23 species were trees in the mangrove environment. According to Tomlinson's (1986) definition, 14 species (six families) were major mangroves, four species (four families) were

minor mangroves and five species (four families) were mangrove associates. Tomlinson's (1986) classification of mangroves divided them according to their features and morphological adaptations: major mangroves are a group of plants that are adapted to a wet, saline habitat, are found exclusively in that mangrove habitat and can form a pure stand. Minor mangroves are groups of plants that do not occur in exclusively mangrove habitats, include inconspicuous vegetation, may occupy peripheral habitats and rarely form pure stands. Mangrove associates are plants present in mangrove habitats that do not show obvious morphological adaptations that can deal with the demanding mangrove habitat and may occur together with terrestrial vegetation.

In the mixed-mangrove area, the three dominant species were *Rhizophora apiculata*, with an importance value (IV) of 29.4% followed by *Avicennia alba* (19.9%) and *Ceriops tagal* (10.6%). The top ten most dominant species as indicated by the IV is listed in Table 2. Of the 14 major mangroves, four -- *Avicennia alba*, *A. marina*, *Sonneratia alba* and *Lumnitzera littorea* -- are listed as protected plants under the 'Wildlife Protection Ordinance Sarawak 1998 (WPOS 1998). *Avicennia alba* and *A. marina* are probably abundant in the area as their timber has limited commercial value. Ecologically these two species are very important as they exhibit a wide physiological tolerance and provide a conducive environment for other mangroves species to become established.

The protected species of special concern is *Sonneratia alba*, because the leaves are a food source for the endangered Proboscis monkey, *Nasalis larvatus*. The distribution of *S. alba* is not widespread, and is confined only to newly formed sandy mudflats in sheltered areas of the park. *Lumnitzera littorea* is a commercially important species and it is threatened by the loss of habitat primarily due to extraction. By protecting this species from continuous extraction it is hoped that this species will continue to flourish. However, it should be noted that none of the species recorded here are listed in the IUCN Red List of threatened species.

Some areas in KNWP are made up of heath forests scattered throughout the interior of the park. The heath forest occurs on higher and drier ground of about 5-6 m a.s.l. and receives no tidal inundation. The heath forests are generally species-rich (73 species) compared with the adjacent mangrove forests and are extremely different from the mangrove forest in structure and species composition. In the heath forest, the two dominant species recorded were *Syzygium ochneocarpa* and *Whiteodendron moultonianum* dominant species with IV at 14% and 12%, respectively (Table 3). Species from the Dipterocarpaceae family such as *Cotylobium* spp.,

Table 1. Species distribution of Kuching Wetland National Park.

Mangrove category	No. of species
Major mangroves	14
Minor mangroves	6
Mangrove associate	5
Non mangrove (Terrestrial flora)	73
Total	98

Table 2. Importance value indices for the ten most dominant mangrove species in KWNP.

No.	Species	Family	IV%
1.	*Rhizophora apiculata*	Rhizophoraceae	29.4
2.	*Avicennia alba*	Acanthaceae	19.9
3.	*Ceriops tagal*	Rhizophoraceae	10.6
4.	*Avicennia marina*	Acanthaceae	8.2
5.	*Excoecaria agallocha*	Euphorbiaceae	5.9
6.	*Ceriops decandra*	Rhizophoraceae	5.3
7.	*Xylocarpus granatum*	Meliaceae	5.1
8.	*Rhizophora mucronata*	Rhizophoraceae	4.1
9.	*Bruguiera sexangula*	Rhizophoraceae	3.1
10.	*Bruguiera parviflora*	Rhizophoraceae	2.5

Table 3. Importance value indices for the six most dominant non-mangrove species in KWNP.

No.	Species	Family	IV%
1.	*Syzygium ochneocarpa*	Myrtaceae	14
2.	*Whiteodendron moultonianum*	Myrtaceae	12
3.	*Diospyros siamang*	Ebenaceae	6.6
4.	*Calophyllum* spp.	Calophyllaceae	5.4
5.	*Knema* sp.	Myristicaceae	5.4
6.	*Cotylelobium* spp.	Dipterocarpaceae	5.3

Dipterocarpus spp., *Hopea* spp., *Shorea* spp. and *Vatica* spp. were also recorded. Other common species include *Dacrydium* spp. and *Garcinia bancana*, *Oncosperma tigillarium* and *Baccaurea* spp.

In general, the species composition in KNWP is rich. The Indo-Malaysian region has 48 mangrove species (Duke *et al*. 1998) and in Sarawak the total number of mangrove species recorded was 40 (Chai 1975). The 14 major mangrove and six minor species recorded in this study can be considered as diverse. In fact, by taking into account the non-mangrove trees species found in the heath forest within the park, KNWP has a high biological diversity of plants.

Stand structure of Kuching Wetland National Park

More than 60% of the mangroves were pole-size with DBH between 5 and 10 cm. None of the trees recorded had a diameter of 30 cm or above. In the mangrove area excluding the heath forest, *Rhizophora apiculata* was recorded at the highest frequency with 548 tree/ha (42%) followed by *Ceriops tagal* at 150 trees/ha (15%) and *Avicennia alba* at 168 (13%) (Table 4). In term of basal area, *Avicennia alba* was recorded as having the highest basal area with 4.5 m^2/ha followed by *Rhizophora apiculata* (3.8 m^2/ha) and *Avicennia marina* (1.3 m^2/ha).

The dominance of pole-size trees indicates that the mangroves are capable of reestablishing themselves by means of seed germinations following extraction. This means that selective extraction of individual mangrove has little impact in terms of regeneration. However, the established mangrove community lacks regular zonation perhaps due to the level of extraction. Moreover, the park consists of extensive interconnecting streams and tidal creeks that make zonation difficult to establish. Meandering streams and irregular canals yield a mosaic community in mangroves (Tomlison, 1994). A comparative study on disturbed and undisturbed mangroves ecosystems in Semporna Sabah showed that the mean DBH in disturbed ecosystems ranged from 10 to 20 cm while a larger DBH of 23 to 35 was common in undisturbed ecosystems (Wah *et al*. 2011). Observers noted that diameter distribution in undisturbed mangroves was symmetrically distributed and irregularly distributed in disturbed mangroves.

Conclusion

Generally there are three forest types in KWNP: mixed-mangrove forests, *Sonneratia alba* (perepat) forest and heath or kerangas forest. Zonation of mangroves in the area is not distinct due to the numerous streams and canals as well as exploitation. More than 60% of the mangroves are pole-size with a DBH between 5 and 10 cm indicating a healthy mangrove forest due to good regeneration of propagules. The species composition in KNWP is rich. Taking into account the non-mangrove tree species found in the heath forest within the park, the plant diversity in KNWP is high.

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Table 4. Tree density and the basal area per ha of six common mangroves in KWNP.

No.	Species	Tree density (No./ha)	Basal area (m^2/ha)
1.	*Rhizophora apiculata*	548	3.8
2.	*Ceriops tagal*	198	0.7
3.	*Avicennia alba*	168	4.5
4.	*Excoecaria agallocha*	80	0.6
5.	*Ceriops decandra*	75	0.09
6.	*Avicennia marina*	65	1.3

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