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Research article

Effect of disturbance on mangrove species diversity in Delta Tumpat, Kelantan, Malaysia

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Abstract: The aim of this study is to determine the diversity of mangrove trees species and forest content such as number of species, trees height, diameter breast height (DBH) and trees density of mangrove species in disturbed and undisturbed area at delta Tumpat, Kelantan, Malaysia. The site selection of undisturbed mangrove areas were the area that far from local settlements and free from any development which is located at Layang-layang Island, Bedal Island, Nelayan Island and Tanjung Duff Island. Whereas, Tujuh Island and Kambing Island were selected as disturbed mangrove area as their location was near to the settlements. A total of ten rectangular plots were established randomly at both area and each plot size is set at 20 x 10m. The sampling area was 0.2 hectare (ha). From the findings, there were five mangrove species identified at both disturbed and undisturbed mangrove area which are *Avicennia marina, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata* and *Sonneratia caseolaris.* The average DBH at undisturbed mangrove area ranges from 3 to12cm, compared to 4 to 8cm in disturbed mangrove area. The range of average height of mangrove species in undisturbed area is 3 to 10m and 1 to 6m for disturbed area. In delta Tumpat, the diversity of mangrove in undisturbed area is higher than in disturbed area calculated using Shannon-Weiner index (H') with 1.54 and 0.38. Species richness community increase as the Shannon-Weiner index increase.

Keywords: Kelantan delta - Distribution - Mangrove - Shannon-Weiner - Disturbance.

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INTRODUCTION

Along the intertidal zones and coastal area in subtropical and tropical countries, there were a colony of mangrove tress with particular root system and adaptation to high salinity nad brackish water condition (Beh *et al*. 2012). Mangroves are adapted to saltwater and flooded soils. It can adapt in much extreme condition but adapt less in cold weather condition. Generally, mangroves do not grow in climate with annual average temperature of less than 19°C. The special ability of mangrove is to regulate salt that allows them to compete with others trees species in the tropical and subtropical tidal environment. Mangrove absorbs the energy of tidal current, storm wind and wave action in order to protect coastal land. Mangrove provides ecosystem purposes on tropical coasts (Gilman *et al.* 2008, Walters *et al.* 2008). Many studies had recorded the biodiversity richness of mangrove area in term of plants and animals (Cannicci *et al.* 2008, Nagelkerken *et al.* 2008). Unfortunately, this forest ecosystem was found degraded by times due to natural and anthropogenic disturbances (Dahdouh-Guebas *et. al*. 2005, Ellison 2008).

DISTRIBUTION OF MANGROVE

The length of Malaysia coastline is estimated at 4,810 km. It is distribute along the West Coast Peninsular Malaysia (1,110 km), East coast Peninsular Malaysia (860 km), Sabah (1,800 km) and Sarawak (1,040 km). There is 641,886 ha of mangrove forest of Malaysia. Sabah consist of 57% of the mangrove area, while Sarawak

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occupied 26% of it. The remaining 17% is located at Peninsular Malaysia (Shukor 2004). Figure 1 shows the wetlands (mangrove and peat swamp forest) areas in Malaysia. Out of the total mangrove area, there are 441,092 ha or 69% of the mangrove land has been gazette as forest reserved (about 74 mangrove forests reserved) in Peninsular Malaysia. Among 74 mangrove forests reserved, 54 areas are on the West Coast, 13 on the East Coast and remaining seven are on the Straits of Johor (Shukor 2004).

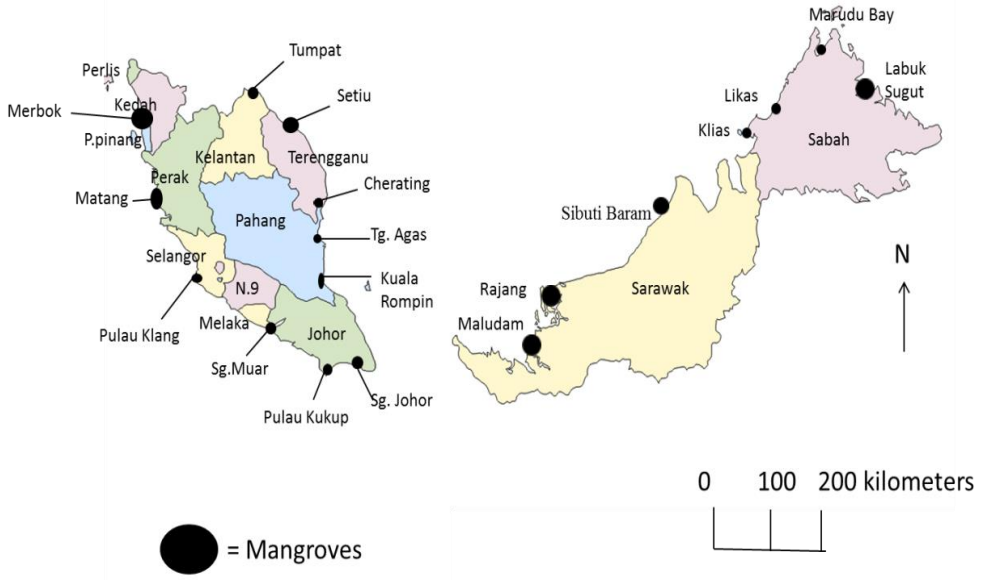

Figure 1. Mangrove Area in Malaysia.

Based on satellite QuickBird data obtained from the Malaysian Remote Sensing Agency, recently mangrove forest area in Tumpat is estimated at 339.6 ha (Satyanarayana *et al.* 2011). Due to seasonal rainfall at delta Tumpat, Kelantan, the bay, mangrove and estuary waterways experienced run-off and offshore currents at north and south that regularly modify the coastal morphology and hydrographical condition in this area (Mohd-Suffian *et al*. 2004).

TYPES OF MANGROVE TREES SPECIES

Mangroves can survive in areas where the water has low content of oxygen, salt water, freshwater and the mixture of fresh and salt water. Mangrove only takes several years to grow and it can reach up to 25 m when they are fully grown. The characteristic of mangrove trees are strong root system, special bark and leaf structures and able to survive in harsh conditions (Jusoff 2013). There are several types of mangrove species found in delta Tumpat which are *Avicennia marina* (Forssk.) Vierh., *Bruguiera gymnorrhiza* (L.) Lam., *Rhizophora mucronata* Lam. and *Sonneratia caseolaris* (L.) Engl. (Satyanarayana *et al.* 2010). Based on previous study by Satyanarayana *et al*. (2011), the overall structure of mangrove forest at Tumpat generally is determined largely by the distribution of *Sonneratia caseolaris*, but the specific area was not stated.

MATERIALS AND METHODS

Study area

This study was undertaken in delta Tumpat, Kelantan. The delta Tumpat located in Tumpat district. The delta is located at the east cost of Peninsular Malaysia, between latitude and longitude of 06º 11.00′ N to 06º 13.00′ N and 102º 10.00′ E to 102º 14.00′ E respectively (Fig. 2). The climate was influenced mainly by the northeast and southeast monsoons, with a mean temperature of 26.8ºC and 83.7% of relative humidity. The delta Tumpat consist of 17 smalls islands with an estimated total area of 1,200 ha where 339.6 ha of the area is covered by mangrove forest. The delta area consist of important forests ecosystem that contributed to social, economic and environmental of local community.

Filed work and sampling plots

There were two types of sampling sites chosen in this study; disturbed and undisturbed areas. The disturbed area is represented by developed, disturbed or manipulated by human which is located at Tujuh Island and Kambing Island, while the undisturbed mangrove areas is located distant from local settlement, consist of intact forest area without any human destruction. The undisturbed area was located at Layang-layang Island, Bedal Island, Nelayan Island and Tanjung Duff Island.

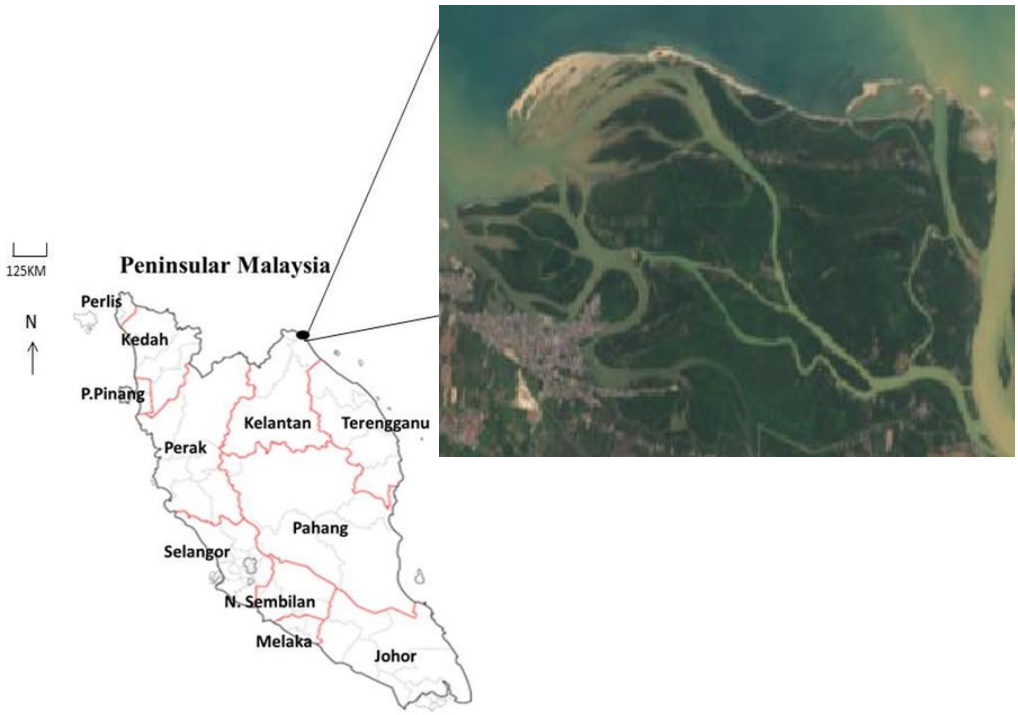

Figure 2. Location of Delta Tumpat, Kelantan.

Sampling plot with size of 20 m × 10 m following method by Wah *et al.* (2011) were set up at the selected sampling sites. The random sampling method was applied in this study. Ten plots were set up at each disturbed and undisturbed areas based on random points created from geographical information system (GIS) map using ArcGIS version 10.2 software by ESRI™.

In the plot, number of individual mangrove trees, species, diameter-at-breast-height (DBH) and tree height were recorded. In this study, mangrove tree species identification is referred to the nomenclatures by Tomlinson (1986) and Duke *et al*. (2010). The tree height measurement was taken using laser distance meter, while DBH were measured using DBH tape. A hand held Global Positioning System (GPS) by GARMIN was utilized to find and record the position of each plot.

Data analysis

The diversity of mangrove trees was calculated using Shannon-Weiner index (H'). The H' is calculated using the formula as in Equation 1:

$$H = \sum_{i=1}^{s} (P_i * \ln Pi) \qquad \text{(Equation 1)}$$

Where:

H = Shannon diversity index

P_i = fraction of the entire population made up of species i

s = numbers of species encountered

RESULTS AND DISCUSSION

The total area covered of both study sites were 0.4 ha. In the disturbed areas, where the area is occupied by local and near to development, the number of mangrove species is lower than in undisturbed area. Only two mangrove species was found in disturbed area which is *Avicennia marina* (Forssk.) Vierh. and *Rhizophora apiculata* Blume. Meanwhile, five dominant species were found in undisturbed area namely *Avicennia marina, Bruguiera gymnorrhiza* (L.) Lam., *Rhizophora apiculata*, *Rhizophora mucronata* Lam. and *Sonneratia caseolaris* (L.) Engl. Table 1 summarized the mangrove vegetation composition structure for different category of sites. The diversity index (H') of disturbed area was found lower compared to undisturbed area with 0.38 and 1.54 respectively. Tree density of disturbed and undisturbed area was found at 1,035 trees/ha and 1,155 trees/ha respectively.

Meanwhile, the details of mangrove tree composition at each category of sites were presented in table 2. Number of individual in undisturbed area is higher than disturbed area. This is because these areas did not encroached by any activity such as land settlement and cutting of trees. Result showed that in undisturbed area,

Avicennia marina has higher number of individuals whereas *Sonneratia caseolaris* has a lower number of individual. *Avicennia marina* has high tolerance to hyper saline conditions (Duke *et al. 2010*). It also a fast-growing species and occasionally planted along with *Rhizophora* and S*onneratia* species. In disturbed area, *Rhizophora apiculata* has higher number of species than *Avicennia marina. Rhizophora* sp. is dominant in mangrove forest in Malaysia due to strong propagule that can grow in sediment with accumulated deposit of mud. Meanwhile, *Avicennia* sp. was found dominant at the seaward sediments, where there is soft and bottomless mud (FAO 1981).

Table 1. Summary of data at disturbed and undisturbed area at Delta Tumpat.

Parameter	Disturbed area	Undisturbed area
Number of tree	207	231
Number of species	2	5
Average tree height (m)	5.54	6.40
Average DBH (cm)	7.37	7.72
H' Index	0.38	1.54

The average DBH at undisturbed mangrove area ranges from 3 to 12 cm, as compared to 4 to 8 cm in disturbed mangrove area. It showed that the DBH in undisturbed mangrove area is higher than disturbed mangrove area. The average height of mangrove species in undisturbed area is higher than disturbed area. The range of trees height for undisturbed area is 3 to 10 m and 1 to 6 m for disturbed area. In both areas, *Rhizophora apiculata* is recorded as the dominant species.

Table 2. Diversity of mangrove in undisturbed and disturbed area at Delta Tumpat, Kelantan.

Category	No. of individuals	Average DBH (cm)	Average Height (m)
Undisturbed area			
Avicennia marina (Forssk.) Vierh.	73	7.06	3.99
Bruguiera gymnorrhiza (L.) Lam.	44	3.76	3.87
Rhizophora apiculata Blume.	58	9.40	9.70
Rhizophora mucronata Lam.	32	11.19	8.52
Sonneratia caseolaris (L.) Engl.	24	8.36	7.58
Disturbed area			
Avicennia marina (Forssk.) Vierh.	26	4.33	1.96
Rhizophora apiculata Blume.	181	7.81	6.05

Based on H' value calculated, undisturbed mangrove areas in delta Tumpat are more diverse compared to disturbed areas comparable to the study by Wah *et al.* (2011). Decreased of diversity in disturbed area at delta Tumpat was predicted due to sand dredging activity. Based on observation made during field survey, several anthropogenic activities were actively threatening the biodiversity of mangrove ecosystem in delta Tumpat. The main threats were the sand dredging activity to deeper the nearest river, development of port, conversion of land for agriculture activity and introduction of invasive species to the area. These activities essentially disturbed the growth of mangrove trees in the area as they dig the sand from the bottom of the river and pool the soil to the land that have mangrove trees. Therefore, the mangrove trees cannot grow well in this condition and being a main reason of the decreasing of species diversity and abundance of mangrove trees in the area.

CONCLUSION

The diversity of mangrove tree species and the forest content in undisturbed and disturbed areas at delta Tumpat, Kelantan are variance. Physically, trees height, DBH and trees density in undisturbed area is higher than disturbed area. Meanwhile, diversity of mangrove in delta Tumpat was analysed using Shannon-wiener index. It showed that the diversity of mangrove in undisturbed area is higher than disturbed area with a value of 1.54 and 0.38 respectively. As the Shannon-wiener index increased, it showed that the place has higher species richness community. It was also found that the main threats of anthropogenic disturbance in this delta was from sand dredging activity to deeper the nearest river, development of port, conversion of land for agriculture activity and introduction of invasive species to the area. Based on this study, delta Tumpat consists of five mangrove species which are *Avicennia marina*, *Bruguiera gymnorrhiza*, *Rhizophora apiculata*, *Rhizophora mucronata* and *Sonneratia caseolaris*. Conservation of these species is very crucial since mangroves plays an important role as habitats for numerous species of coastal and aquatic flora and fauna as well as preventing coastal erosion and as insulator for tidal and waves.

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