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Vegetation and Community Structure of Mangrove in Bama Resort Baluran National Park Situbondo East Java

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History Article

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Bama Resort; Mangrove Community; Mangrove Diversity; Mangrove Zonation

Abstract

Ecotourism development program at Bama beaches area require baseline data of mangrove structure at Bama Resort and in the past two decades has been lost about 35% area of mangrove forest in Indonesia and in the worldThe aims of this study was to find structure, composition, distribution and zonation patterns of mangroves at Bama Resort Baluran Nasional Park. Ten belt-transects were laid perpendicular to the shoreline, using standard methods. Vegetation structure was determined using data collected on plant species diversity, density, basal area, and the number of each species of mangroves. Shannon Wiener index to calculated diversity, evennes and Simpson to calculated dominance index. The results show there are 2 families and 6 mangrove species occurring in the study areas that is Rhizophoraceae (*Rhizophora stylosa*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera gymnorrhiza,* and *Ceriops tagal*) and Araceae (*Nypa fruticans*). The highest importance value was *R. apiculata* (229.90%) for trees, *R. apiculata* (148.69%) for the sapling, and *R. apiculata* (244.83%) for the seedling. The diversity (H) and dominance index (C) values were moderate (1.79) and 0.521. The most dominant species was *R. apiculata* (C=0.487). The mangrove zonation pattern from coastline to the mainland was *R. stylosa*, *R. mucronata*, and *R. apiculata*, in the outer zone, respectively (zone directly adjacent to the sea); *B. gymnorrhiza* and *C. tagal* in the middle zone; and *N. fruticans* in the zone that adjacent to the mainland. The present study will aid in the conduct and preservation planning of mangrove forest especially at Bama coast and generally in the coastal areas of Indonesia.

How to Cite

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INTRODUCTION

Mangroves are one of forests ecosystem that unique and special. The mangrove ecosystem exists in tidal coastal areas, beaches, and some small islands. Mangrove forests harbor a valuable natural resource with high intrinsic natural productivity. Mangrove are woody plants, which grow in loose wet soils of brackish-to-saline estuaries and shorelines in the tropics and sub-tropics (Joshi & Ghose, 2003; Giri et al., 2010). Mangrove forests provide many valuable ecosystem services, such as assimilating excess atmospheric carbon, protecting coastlines from hurricanes, increasing vertical land development, and providing nursery habitat for fish (Nagelkerkin et al., 2008; Lee et al., 2014).

The mangrove ecosystem in Indonesia holds 75% of total mangroves in South East Asia or around 27% of total mangroves in the world. Besides that, mangrove ecosystem in Indonesia has the highest diversity in the world (Spalding, et al., 2010; Giri, et al., 2010; Sukardjo & Alongi, 2012). The distribution of mangroves in Indonesia is located on the coast of Sumatra, Kalimantan, and Papua. The extent of mangroves distribution continued to decline from 4.25 million hectares in 1982 to approximately 3.24 million hectares in 1987 and remaining of 2.79 hectares in 2000 (Richards & Friess, 2016). Between 2000-2012, the percentage of mangroves loss were 1.72% (Giri et al., 2008; Richards & Friess, 2016). The declining trend indicates that there were 61,000 hectares of mangrove forests deforestation and mangrove habitat loss of 48,000 hectares over 12 years (Richards & Friess, 2016). It is caused by the conversion of land used into aquaculture/farming, agriculture, tourism, urban development, and overexploitation (Giri et al., 2008; UNEP, 2014; Richards & Friess, 2016).

One result of various human activities in the coastal areas that affect the sustainability of natural resources is the destruction of mangrove ecosystem (Alongi 2009; Van Oudenhoven et.al., 2012). The existence of mangrove ecosystems play an important role for the continuity of ecological and hydrological processes. Damage and disturbance to the growth state could be a problem for the regeneration of mangroves in the future.

The growth of each plant will adjust to surrounding environment so that the morphology that occurs will vary from one place to another (Gratani, 2014). Therefore, the morphology of mangroves in Baluran National Park is typical, considering that the different environmental conditions have different morphological descriptions (Sudarmadji, 2003).

The ecotourism development program in Bama Beach area requires data of mangrove ecosystem structure in Bama Beach Baluran National Park. This research aimed to know the community structure of mangrove ecosystem that includes mangrove species, diversity, domination, and zonation pattern in Bama Resort Baluran National Park, which can be used in the management and conversation of mangroves especially in Baluran National Park and generally in East Java.

METHODS

The study area

The research was conducted in January-May 2014 at Bama Beach Baluran National Park. Baluran National Park is located at Situbondo District East Java Province (Figure 1) geographically lies between 7°50'44.48' S- 114°27'39.65" E and 7°51'04.11" S -114°27'32.32" E. Mapping transects and plots in sampling area was obtained through Global Positioning System (GPS) by the use of an online mapping (Figure 2).

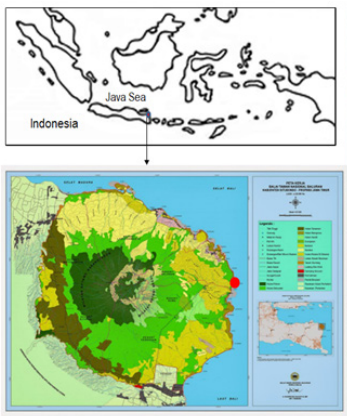

Figure 1. The research site

Figure 2. Sampling transects in Bama Beach

The research procedures were by conducting survey and imaging via Google Earth which allegedly representing and depicting mangrove zonation pattern then determined ten transects with length adjusting the mangrove thickness.

Establishment of sampling plots and measurement

We used quadrat transect methods with ten transects belt that perpendicular to the mainland, each sub-plot (100 m^2) for sapling (dbh: 2cm-9.99cm) and trees (dbh: ≥ 10cm), and a 5 x 5-meter plot was laid inside the main plot for seedling (dbh: < 2.0cm) study. Mangroves trees inside the sampling plots were counted and identified respectively. The data collected of this research were mangrove species, number of stem to determine the value of density, tree diameter at breast height (dbh), stem height, substrate type (fraction), and physical-chemical condition such as pH, temperature, salinity, and light intensity.

Vegetation analysis

The data were analyzed using several parameters: population density, frequency, dominance, relative density, relative frequency, relative dominance, and the importance value (Legendre & Legendre, 2012). This analysis can better inform of species function in its habitat. It also gives order for appropriate species within the mangrove community.

$$\text{Population density} = \frac{\textit{Number of individuals}}{\textit{Total area sampled}}$$

$$\text{Frequency} = \frac{\textit{Number of plots in which a species ocurs}}{\textit{Total number of plots sampled}}$$

$$\text{Dominance} = \frac{\textit{Total of basal area of each tree of a species from all plots}}{\textit{Total area of all measured plots}}$$

$$\text{Relative density} = \frac{\textit{Number of individual of a species}}{\textit{Total number of individuals all of species}} \times 100$$

$$\text{Relative dominance} = \frac{\textit{Total basal area of a species}}{\textit{Basal area of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\textit{Frequency of species}}{\textit{Total frequency of all species in different plots}} \times 100$$

Importance value (*IV*) = Relative density + Relative frequency + Relative dominance

Diversity index of mangroves was calculated by Shannon-Wiener index (Legendre & Legendre, 2012).

$$H' = -\sum Pi \ln Pi$$

H = Shannon diversity index

*P*i = Fraction of the entire population made up of species *i* (proportion of a species *i* relative to total number of species present)

$$\text{Evennes index (J)} = \frac{H'}{H\ max}$$

Dominance index was calculated by Simpson (Legendre & Legendre, 2012).

D =^{2}

D = dominance index

ni = importance value for each species

N = total of importance value

Water Analysis-

Water in all plots were measured pH, salinity, and temperature. The measurement have been carried out in situ. Light intensity on each plots was measured using lux meter

Light Intensity-Substrat Analysis

The determination of texture of mangrove substrate was done ex situ in the laboratory. Soils in all plots were collected using a stainless steel corer (7 cm inside diameter) to a depth of 20 cm. Soils samples each plot were taken twice. The steps in substrate texture analysis are based on the USDA triangle.

RESULTS AND DISCUSSION

Overview of the Research Site

The research site was located at Bama Resort which include in Baluran National Park area with 6.126 ha. 6 species mangroves from 2 families were recorded in this research, that is family Rhizoporaceae (*R. stylosa*, *R. mucronata*, *R. apiculata*, *B. gymnorrhiza,* and *C. tagal)* and family Araceae (*N. fruticans*) (Table 1) and Figure 4.

All of these mangroves are mayor mangrove or true mangrove. *R. apiculata* was the most abundant tree with 221 trees followed by *R. stylosa* (50 trees), *B. gymnorrhiza* (11 trees), *R. mucronata* (3 trees) and *N. fructicans* (3 trees). Moreover *R. apiculata* sapling showed the highest dispersal followed by *R. stylosa, N. fructicans, B. gymnorrhiza, R. mucronata,* and *C. tagal*. When considering the seedlings, *R. apiculata* was the highest dispersal (13 trees), followed by *B. gymnorrhiza* (2 trees). The success of *R. apiculata* regeneration at the sea edge due in part to differences infloading tolerance of these species (Sukardjo et al., 2014). It's also could be due to *R. apiculata* has the highest tolerance limit of the extreme conditions such as high salinity and muddy substrate. That highest tolerance limit is supported by the root system of *R. apiculata* which is aerial root (pneumatophore) in the form of long roots and branches arise from the base of stem. This root is known as the prop root and will eventually become still root if the stem is held up so that it no longer touches the ground. The root helps the upright of the tree because it has a broad base to support in soft and unstable mud. It also helps the aeration when exposed at low tide (Ng & Sivatoshi, 2001; Hogarth, 2015).

From this data, total number of seedling

Table 1. The total number of seedlings, saplings, and trees of all mangrove in a 0.3 h at Bama resort

Species	Family	Stage		
		Seedlings	Saplings	Trees
R. stylosa	Rhizophorazeae	0	48	50
R. mucronata	Rhizophorazeae	0	5	3
R. apiculata	Rhizophorazeae	13	81	221
B. gymnorrhiza	Rhizophorazeae	2	16	11
C. tagal	Rhizophorazeae	0	2	0
N. fructicans	Araceae	0	26	3
	Total	15	178	288

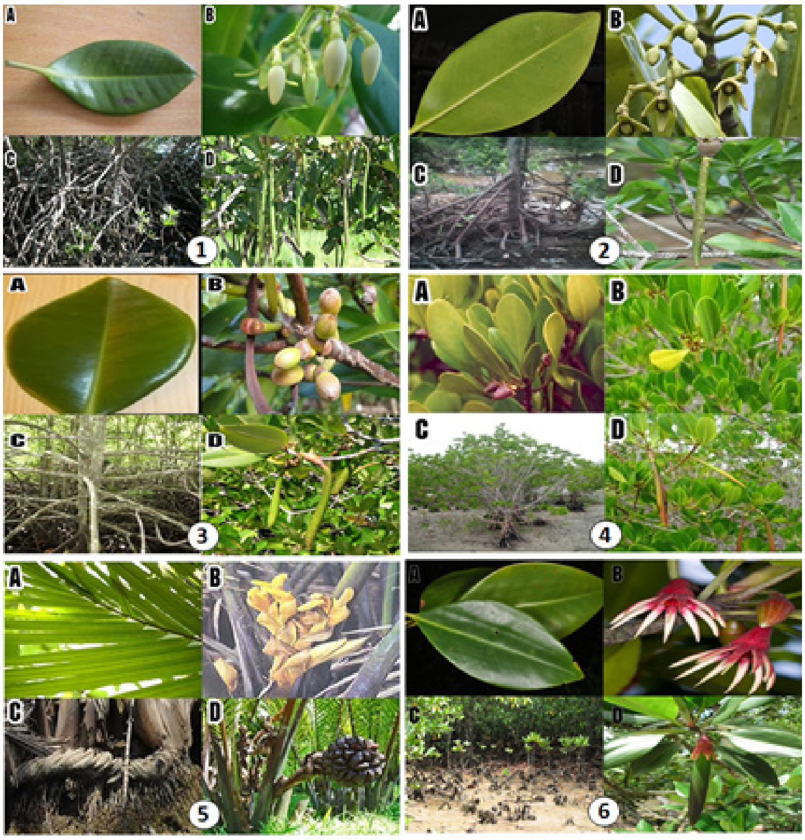

Figure 3. Mangrove species recorded in Bama Resort: *1. R. stylosa. 2. R. mucronata. 3. R. apiculata. 4. C.tagal. 5. N. fruticans. 6. B. gymnorrhiza*. A. leaf. B. flower arrangement. C. rooting system. D. propagul.

all plots showed a pure regeneration potential, only *R. apiculata* and *B. gymnorrhiza.* Hastuti & Budihastuti (2016) has indicated that environment parameters including temperature, turbidity, pH, DO and its changes had significant effect on the growth of mangrove seedling especially *R. mucronata*.

The water temperature is still classified as a normal range between 28°C -29°C, salinity is quite good for the growth of mangrove that range 29ppt -31ppt, and the water pH is normal in the range 6.8-7.5. Soil in all plots consisted of a mixture of dark gray silt-clay (71-74%) with lesser amounts of sand (19-26%).

The intensity of the light is in the range of 900 lux until more than 3000 lux, the light intensity of the different areas of the outside and the inside of the mangrove forests. The outer area got more sunlight compared to other areas in the central part of or inside of the mangrove forests, so the value is also different, although there are some parts in the area of mangrove forests also

Table 2. Analysis of mangroves trees

Species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	Importance value (%)
R. apiculata	75.00	62.29	82.74	229.80
R. stylosa	17.31	20.27	10.63	47.78
B. gymnorrhiza	3.85	10.14	5.75	15.57
N. fruticans	1.92	4.38	0.44	3.42
R. mucronata	1.92	2.92	0.44	3.34
Total	100.00	100.00	100.00	300.00

got sunshine that's a lot, this caused the existence of an open canopy or the presence of uprooted trees caused the sunlight may enter among the vegetation. Areas with more sunlight supports the process of the growth of mangroves or other organism is better compared to the darker areas and dense.

Table 2 indicated the result of quantitative analysis for tree-level based on importance value index. Its shows that there were 5 tree level mangrove species in the research site. The most important species was *R. apiculata* with the importance value at 229.80% and the least important species was *R. mucronata* with the importance value at 3.34%. In this study did not found *Avicenia marina* such mangrove species as is common to other mangrove forest bordering the Java Sea. Hogarth (2015) has been reported *A. marina* can grow where the soil salinity is greater than 65%0.

Diversity is the total range of plant species in an area Diversity index or Shannon diversity index is used to determine the species diversity in a community. Species evenness is a measure of biodiversity which quantifies how equal the populations are numerically (Legendre & Legendre, 2012). Evenness index (J) which is the relative abundance with each mangrove species is represented in an area. In this research, the value of diversity index is 0.39 for seedling, which is low as shown in Table 3. Although the diversity index is relatively low, there were 6 species mangroves belonging to mayor mangrove or true mangrove, so it is important to maintain the mangroves. Bama Resort area has a low diversity because there was *R. apiculata* which has the sub-dominant or dominant but not a whole characteristic. This occurs because the ecosystem conditions that strongly support the growth of *R. apiculata* which is the type of substrate (mud).

Species diversity and mangrove growth are influenced by salinity (Ball, 2002; Friess, et al., 2012; Atwell, et al., 2016), competition and other physical factor (Hogarth, 2015, Hossain & Nuruddin, 2016). Setyawan, et al. (2008) added that the extent of the mangroves area greatly determines the diversity of plant species. The extent of area also allows sufficient space to grow and reduce competition among species in the fight for space, nutrition, and space.

Table 3. Shannon diversity (H') and Evenness (J)

Category	Shannon Diversity (H')	Evenness (J)
Seedlings	0.39	0.22
Saplings	1.37	0.76
Trees	0.73	0.41
All species	1.79	0.49

\

Table 4 shows that research plot with the Simpson dominance index (D) at 0.521, which classified as sub-dominant because the D value is in between 0.5 and 0.75. Based on this results, it is known that there were sub-dominant mangrove or non-dominant. *R. apiculata* has the highest dominance value (0.487), which also has the sub-dominant characteristic (Table 4).

Table 4. Dominancy index of mangrove vegetations

Species	Dominance Index
R. stylosa	0.029
R. mucronata	0.000
R. apiculata	0.487
B. gymnorrhiza	0.004
C. tagal	0.000
N. fruticans	0.001
Total	0.521

The mangrove zonation pattern in the research site from the coastal line to the mainland was *R. stylosa*, *R. mucronata*, and *R. apiculata* in the outer zone, respectively (zone directly adjacent to the sea); *B. gymnorrhiza* and *C. tagal* in the middle zone; and *N. fruticans* in the zone that adjacent to the mainland or landward zone (Figure 4). The three zones of mangroves in Bama resort are not similar to those found throughout the Sirondo and Batu Sampang Baluran National Park (Sudarmadji, 2003), the Cimanuk Delta (Sukardjo et al., 2014). The principal drivers of zonation are complex (Alongi, 2002), dependent on the interrelationships between and among factors, including soil nutrients, frequency of tidal inundation or different positions along some physical gradient, ecological interactions between species in the community (Hogarth, 2015). The percentage of the most dominant substrate fraction is mud with total percentage of 10 transects at 48.76%. This result indicated that the type of the research site was coastal akressif.

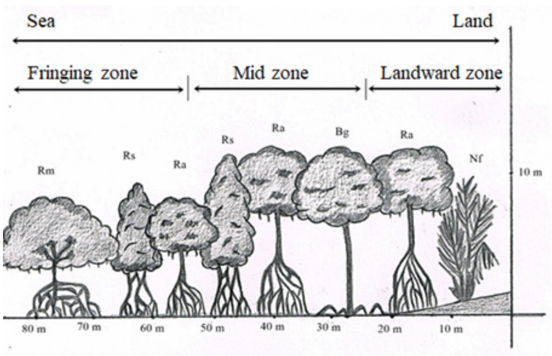

Figure 4. The mangrove zonation pattern at the research site *Rm : R. mucronata Rs : R. stylosa Ra : R. apiculata Bg : B. gymnorrhiza Nf : N. fruticans*

Zoning is almost entirely dominated by *R. apiculata* from the coastal line to the mainland (Figure 5), except at transect 5 which is only found saplings of *N. fruticans* at the coral sand substrate. This condition is more influenced by the adaptability of *R. apiculata* which is fairly high. Besides that, its shorter and slender hypocotyl than the Rhizophoraceae group allow to be carried by the sea water (Hogarth, 2015).

Figure 5. The rooting appearance of *R.apiculata* located in the middle zone

Based on the results, it can be concluded that there were 6 species mangroves from 2 families in Bama Resort Baluran National Park, that is family *Rhizophoraceae* (*R. stylosa*, *R. mucronata*, *R. apiculata*, *B. gymnorrhiza*, and *C. tagal*) and family Araceae (*N. fruticans*). The diversity of mangroves in Bama Resort Baluran National Park was classified as good (1.79). There is not mangrove which classified as dominant in Bama Resort Baluran National Park area. But, *R. apiculata* has sub-dominant characteristic with the dominance value at 0.487. The mangrove zonation pattern from the coastal line to the mainland was *R. stylosa*, *R. mucronata*, and *R. apiculata*, in the outer zone, respectively (zone directly adjacent to the sea); *B. gymnorrhiza* and *C. tagal* in the middle zone; and *N. fruticans* in the zone that adjacent to the mainland or landward zone.

This study identified that arrangement of mangroves in Bama resort is slightly different from the type of zoning compiler in general. There is not found of Avicenniaceae or Verbenaceae family, and the mangroves of Bama resort did not have dominant species.

The present study will aid in the conduct and preservation planning of mangrove forest especially at Bama coast and generally in the coastal areas of Indonesia.

CONCLUSIONS

A total of six mangrove species (*R. stylosa*, *R. mucronata*, *R. apiculata*, *B. gymnorrhiza*, *C. tagal*, and *N. fruticans*) from two families (*Rhizophoraceae* and *Araceae*) were identified in Bama Resort. Analysis in vegetation in Bama Resort showed that species with highest importance value was *R. apiculata* (229.80%) followed by *R. stylosa* (47.78%), *B. gymnorrhiza* (15.57%), *N. fruticans* (3.42%), and *R. mucronata* (3.34%). The greatest mangrove diversity (1.37) in terms of diameter category is sapling and the lowest mangrove diversity (0.39) was belongs to seedling. The mangrove zonation patterns from the coastline to the mainland are *R. stylosa*, *R. mucronata*, and *R. apiculata* in the outermost zone (the zone adjacent to the sea), *B. gymnorrhiza* and *C. tagal* in the middle zone. *N. fructicans* in the zone bordering on land mangrove.

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