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Composition, abundance and distribution of mangroves in Bacolod, Lanao del Norte, Mindanao, Philippines

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Abstract. The composition, abundance and distribution of mangrove species in Bacolod, Lanao del Norte were analyzed. Majority of the sampling areas were dominated by *Sonneratia alba*, *Rhizophora apiculata* and *Rhizophora mucronata*. The top three sampling stations which had the highest total density were Liangan East, Poblacion and Rupagan. These areas have also higher regeneration potential of mangroves including Demologan. Consequently, the mangrove area in Bacolod is relatively stable with less human disturbance.
Key Words: mangrove, seedling, sapling, distribution, abundance, *S. alba*, *R. apiculata*, *R. mucronata*.

Introduction. Mangrove is a type of forest growing along tidal mudflats and along shallow coastal water extending inland along rivers, streams and their tributaries where the water is generally brackish (Melana et al 2000). Mangrove forests have important ecological and socio-economic values to man (Bennet & Reynolds 1993). Mangrove trees provide timber for construction, firewood and charcoal, fishing poles, pulp and tannin (Hamilton & Snedaker 1984). Many parts of the mangrove can also be used for medicines (Bandaranayake 1998). Mangrove leaves support the marine food web through the production of detritus, which provides an important food source for shrimp and fish (Leh & Sasekumar 1984), molluscs, crabs, birds and many other animals (Macintosh 1984); this in turn supports the coastal fisheries (Chong et al 1990). Mangroves provide protection and a habitat that is suitable as breeding and nursery areas for many shrimp, crabs and marine fish (Sasekumar et al 1992; Barbier & Strand 1998). Mangroves also provide important regulatory functions. They reduce coastal erosion and flooding, buffer salinity changes and intrusion, supply and regenerate nutrients and retard run-off (Lugo & Snedaker 1974; Othman 1994; Tri et al 1998). The diverse plant and animal life associated with mangrove ecosystems can also provide opportunities for nature education, tourism and scientific study, thereby providing further social and economic values.

The Philippines is an archipelago of around 7,100 islands bordered by 36,300 km of coastline along mangrove forests, seagrass beds and coral reefs. An estimated total mangrove area of 500,000 ha was found within the Philippine coastlines in 1918 (Brown & Fischer 1920). But studies showed that 70% of the original mangrove forest was lost from 500,000 ha in 1918 to 120,500 ha in 1994 with depletion rate of 3,700 ha per year from 1980-1991 (Giesen et al 2006; Maneja 2006). Cutting trees for production of firewood, charcoal and building materials is the primary factor in the decline of mangroves. But the most rapid decrease of mangroves occurred during 1960's and 1970's when the national policies encouraged aquaculture expansion for fish and shrimp production (Deguit et al 2004). Other factors of mangrove depletion include urban and industrial development, conversion to agriculture and housing projects (Maneja 2006).

Bacolod is located along the coast of Iligan Bay which is connected to Panguil Bay. It has an estimated mangrove area of 29,085 ha. This mangrove ecosystem is one of the most important coastal ecosystems found in this area. However, there has been little scientific work done to study this habitat. As a result, its ecological, social and economic benefits have largely been unrecognized. In this study, the composition, abundance and distribution of mangrove species were analyzed. This information is useful for future monitoring and proper management of this important marine resource.

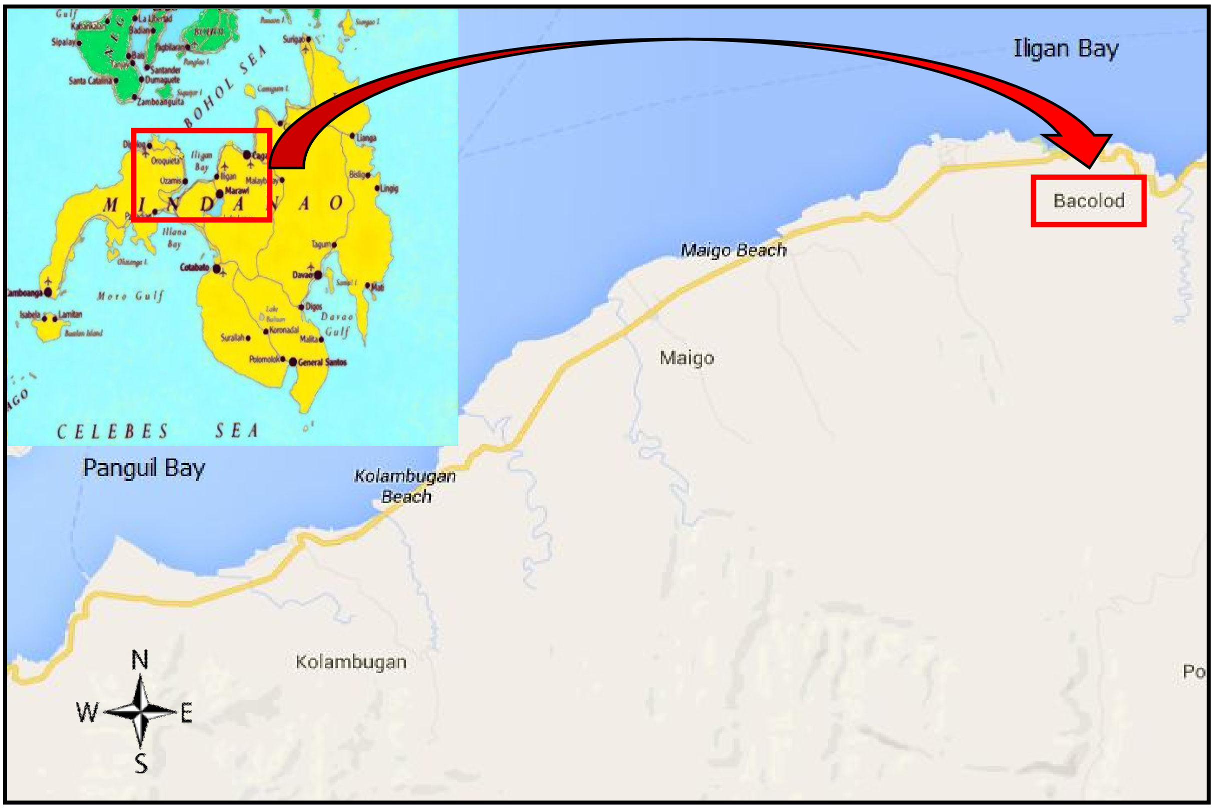

Figure 1. Map showing the sampling area of Bacolod, Lanao del Norte. Inset is the Mindanao Island (Source: https://www.maps.google.com.ph).

Material and Method. The study was conducted in Bacolod, the fourth coastal municipality of Lanao del Norte (Figure 1). It is located in the northern part of Mindanao. Bacolod has a land area of 10,410 ha and a coastal length of 2,470 km. It has a tropical climate. The rainfall in Bacolod is significant, with precipitation even during the driest month. The average annual temperature is 27.1^{o}C and the average annual rainfall recorded was 3,066 mm (Regional Forecasting Center and Surface Synoptic Station, Molugan PAGASA Complex, Molugan, El Salvador, Misamis Oriental). The municipality is comprised of sixteen (16) barangays, seven (7) of which are coastal barangays (Rupagan 8º11'41"N, 124º3'41"E; Minaulon 8º11'50"N, 124º3'2"E; Demologan 8º11'52"N, 124º3'40"E; Binuni 8º11'60"N; 124º3'1"E; Poblacion 8º11'56"N; 124º3'8"E; Esperanza 8º11'56"N, 124º3'6"E and Liangan East 8º11'50", N 124º3'50"E) and were considered as the sampling stations. Rupagan has two river tributaries while Esperanza and Liangan East have one tributary each. Minaulon, Demologan, Binuni and Poblacion have streams. The soils in the area are made up of sand, loam and clay.

The study was conducted from November 2014 to January 2015. Assessment of mangroves was determined using the transect-quadrat method (English et al 1997). Mangroves were classified based on height (Ashton & Macintosh 2002) as to mature tree (> 4 m), sapling (1-4 m) or seedling (< 1 m). A 100 meter transect line was pegged perpendicular to the shore with a 10 meter interval between transects and within that transect line a 100 cm x 100 cm quadrat was set up. The trees, saplings and seedlings within the quadrat were counted per species and the values were expressed as density (number of trees ha^{-1}). Height of trees (meter) was measured using a modified clinometer applying trigonometric techniques. The girth (or diameter in meter) at a standard breast height of 1.3 m was measured using a tape measure following the standard method of English et al (1997). The diameter at breast height or DBH (meter) was calculated using the formula: circumference/3.1416 and the basal area (BA) were computed using the following formula: 3.1416 (DBH)^2/4 (English et al 1997). Mangroves were identified using the taxonomic keys of Calumpong & Meñez (1997) and Melana & Gonzales (2000). The difference in density, basal area and height among species and sampling area was analyzed through Multivariate Analysis of Variance (MANOVA, level of significance, p of 0.05) in SPSS (version 20).

Results and Discussion. Eleven species of mangroves were identified namely *Sonneratia alba* (J. Smith), *Rhizophora mucronata* (Lamarck), *Rhizophora apiculata* (Blume), *Aegiceras corniculatum* (Linnaeus) Blanco, *Aegiceras floridum* (Roemer and Schultes), *Avicennia alba* (Blume), *Bruguiera cylindrica* (L.) Blume, *Lumnitzera racemosa* (Willdenow), *Lumnitzera littorea* (Jack) Voigt, *Scyphiphora hydrophyllacea* (Gaertner f.), and *Nypa fruticans* (Thunberg) Wurmb. This species number was lower compared with the rich mangrove ecosystems in the country, such as Pagbilao Bay in Quezon Province [37 species (Almazol et al 2013)]; Panay [34 species (Primavera et al 2004), Guimaras [30 species (Sadaba et al 2009)], Davao Gulf [30 species (Flores 2003)], Bohol [26 species (Mapalo 1992)], Samar Island [22 species (Mendoza & Alura 2001)], Ibajay in Aklan Province [22 species (Primavera 2000)], Palawan [22 species (Arquiza 1999)] and Danao Bay [20 species (De Guzman 2004)]. This difference could be attributed to the environmental factors present in each area (Tomlinson 1986), and likewise the size of the mangrove area. Based on ocular estimates from transect mapping, the mangrove area in Bacolod was found to be 15.95 ha. This was relatively smaller than the mangrove area in Pagbilao Bay in Quezon Province [145 ha (Almazol et al 2013)]; Panay [117.7 ha (Primavera et al 2004)], Guimaras [577.08 ha (Sadaba et al 2009)], Davao Gulf [2,683 ha (Flores 2003)], Bohol [425 ha (Mapalo 1992)], Samar Island [10,140.6 ha (Mendoza & Alura 2001)], Ibajay in Aklan Province [75 ha (Primavera 2000)], Palawan [42, 300 ha (Arquiza 1999)] and Danao Bay [2, 279 ha (De Guzman 2004)].

The compositions of species were relatively similar in seven sampling stations (Table 1). Most species were common across the stations except for *S. hydrophyllacea* (Nilad), which was found only in Minaulon; *L. littorea* (Sagasa) which was found only in Esperanza and; *L. racemosa* (Kulasi or Mayoro) which was found only in Liangan East. These species were found in the landward zone where tidal inundation was rare hence distribution is limited (IUCN 2010). Majority of the sampling areas were dominated by *S. alba*, *R. apiculata* and *R. mucronata*. *Nypa fruticans* (Nipa) known to be associates but are now considered “true” mangroves, was commonly found in the inner reaches of the mangrove ecosystem in all of the sampling areas.

The abundance of mangroves varied across species and sampling area ($p < 0.05$, Table 2). The top three stations which had the highest total density were Liangan East (76,900 trees ha^{-1}) followed by Poblacion (71,700 trees ha^{-1}) and Rupagan (65,000 trees ha^{-1}), respectively (Figure 2). This result was attributed to the size of the mangrove area and the number of trees present. Based on ocular estimates from transect mapping, Liangan East had a mangrove area of 2.35 ha, Poblacion had 3.5 ha and Rupagan had 2.5 ha, respectively. Also, Liangan East and Rupagan had river tributaries which contributed to the abundance of mangroves. Highest productivity values are usually reported in mangroves associated with rivers (Twilley et al 1986). The canopy height and basal area was highest in Binuni (4.01-55.88m), Poblacion (4.00-44.26m), Rupagan (4.00-42.95) and Liangan East (4.00-42.95) indicating that the mangrove trees present in these areas were already mature (Table 3). Likewise, this result indicates less utilization of trees (i.e. tree cutting) in the area. In addition, this mangrove structure is better than in Liloan, Cebu which has 6,033 trees ha^{-1} with only 0.73 m^{-2} basal areas (Dacles et al 1995).

Table 1

Occurrence of mangrove species in seven (7) coastal barangays of Bacolod, Lanao del Norte

Area	*Species*										
	Sa	*Rm*	*Ra*	*Ac*	*Af*	*Aa*	*Bc*	*Ll*	*Lr*	*Sh*	*Nf*
1. Rupagan	+	+	+	+	-	+	+	-	-	-	+
2. Minaulon	+	-	+	+	-	+	-	-	-	+	+
3. Demologan	+	+	+	-	-	+	-	-	-	-	+
4. Binuni	+	+	+	-	-	+	-	-	-	-	+
5. Poblacion	+	+	+	-	-	+	-	-	-	-	+
6. Esperanza	+	+	+	-	+	+	-	+	-	-	+
7. Liangan East	+	+	+	-	+	+	+	-	+	-	+

Legend: (+) present; (-) absent; Sa is *S. alba*; Rm is *R. mucronata*; Ra is *R. apiculata*; Aa is *A. alba*; Ac is *A. corniculatum*; Af is *A. floridum*; Bc is *B. cylindrica*; Sh is *S. hydrophyllacea;* Ll is *L. littorea*; Lr is *L. racemosa* and Nf is *N. fruticans*.

Table 2

Statistical analysis (Multivariate Analysis of Variance) on the effects of species and sampling area on density (number of trees ha^{-1}), height (m) and basal area (m^{-2}) of mangroves in Bacolod, Lanao del Norte

Dependent variable	*Independent variable*	*d.f.*	*F-statistics*	*p*	*Analysis*
Density	Species	10	18.707	0.000	Sig.
	Area	6	4.640	0.000	Sig.
	Species x Area	29	2.225	0.000	Sig.
Height	Species	9	13.983	0.000	Sig.
	Area	6	5.340	0.000	Sig.
	Species x Area	24	2.189	0.001	Sig.
Basal Area	Species	9	1.975	0.038	Sig.
	Area	6	0.039	0.997	N.S.
	Species x Area	24	0.055	0.897	N.S.

Legend: Sig. is significant; N.S. is not significant.

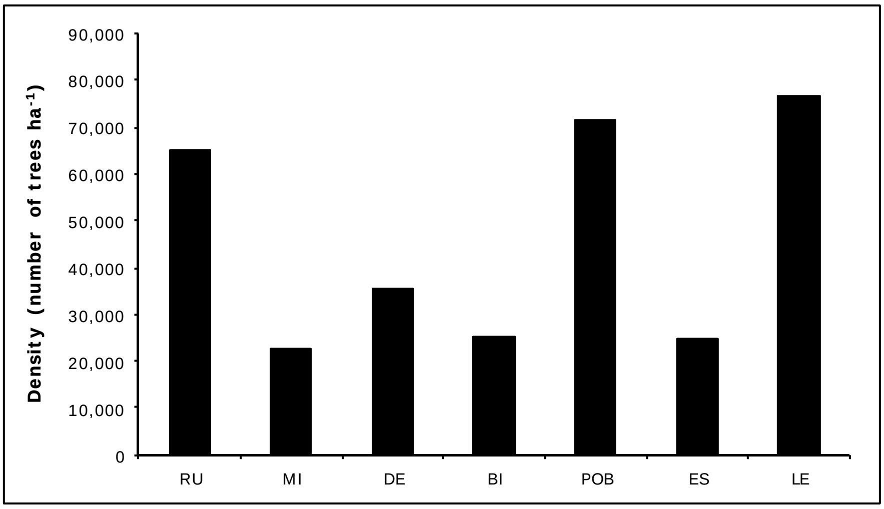

Figure 2. The total density of mangroves in Bacolod, Lanao del Norte. Legend: RU (Rupagan), MI (Minaulon), DE (Demologan), BI (Binuni), PO (Poblacion), ES (Esperanza) and LE (Liangan East).

Table 3

The height (m) and basal area (m^{-2}) of mangrove trees in Bacolod, Lanao del Norte

Variable	Range value	
	Height	*Basal area*
1. Rupagan	4.00-25.26	0.046-462.06
2. Minaulon	4.00-26.15	0.082-117.06
3. Demologan	4.00-27.47	0.082-123.34
4. Binuni	4.00-34.35	0.082-320.88
5. Poblacion	4.01-27.35	0.046-1025.82
6. Esperanza	4.02-28.74	0.082-40.67
7. Liangan East	4.07-22.69	0.046-78.94

The height is a useful criterion in forest stand classification. According to Kasawani et al (2007), a stand height > 20 m is considered as old stand. The height of mangrove trees in Bacolod, Lanao del Norte ranged from 4-34 m hence classified as old stand. This result indicates that the mangrove ecosystem in Bacolod had minimal human disturbance. They were not much frequented by people though they were near the community. In fact, Poblacion which is the center of population obtained higher density, biomass and basal area. In addition, the highest canopy height indicates less utilization of mangrove trees for economic activities in the area.

Mangrove seedlings and saplings of the three dominant species (*S. alba*, *R. apiculata* and *R. mucronata*) contributed to the recruitment in Bacolod. The total number of seedlings and saplings of *S. alba* was 849 and 2,497, respectively. It was followed by *R. mucronata* with 445 seedlings and 491 saplings, respectively. *R. apiculata* ranked third with a total of 283 seedlings and 256 saplings. Other species had no or only few recorded seedlings and saplings. Poblacion and Liangan East had the highest total number of seedlings with 45,800 and 41,300 seedlings, respectively. On the other hand, Rupagan, Poblacion and Demologan had the highest total number of saplings with a number of 77,300, 67,200 and 64,500 saplings, respectively. The highest numbers of sapling and seedling in the area implies the large capacity or potential of the mangrove community to regenerate and replace what might have been lost due to natural causes (e.g. death of old trees) or human impacts such as tree cutting. The large proportion of saplings over seedlings also implies high growth rate of seedlings. Gan (1995) recommended a density of 5000-10000 seedlings per hectare to ensure good regeneration potential for cleared area while Srivastava & Ball (1984) cited that a minimum of 2,500 seedlings per ha is required to qualify natural regeneration as being sufficient. In this case, regeneration potential of mangroves in Bacolod is relatively higher especially in Rupagan, Poblacion, Demologan and Liangan East (Figure 3). However, this observation should be taken with caution since many of the mangrove forests in Bacolod have been reforested. While seedlings and saplings of *S. alba* (Pagatpat) are probably from natural recruitment, most of the seedlings of *Rhizophora* (Bakawan) are obviously planted and cannot be attributed to natural regeneration. The abundance of sapling and seedling can be attributed to higher canopy height of the mature mangrove trees in the area because seedlings are apparently adapted for shaded understory environment (Farnsworth & Ellison 1996).

Based on inundation (flooding during high tide) level (per observation), the mangroves in Bacolod showed a typical zonation pattern. Species found in the landward zone (inundation level: 0-5 cm) were *N. fruticans*, *S. hydrophyllacea, A. corniculatum, A. floridum, B. cylindrica, L. littorea* and *L. racemosa.* In the central part of the forest (inundation level: 10-15 cm), *A. alba* and *R. mucronata* were found and in the seaward zone (inundation level: 19-48 cm) were the *R. apiculata* and *S. alba*. The same zonation was observed in Tiniguiban Cove, Puerto Princesa (Becira 2005).

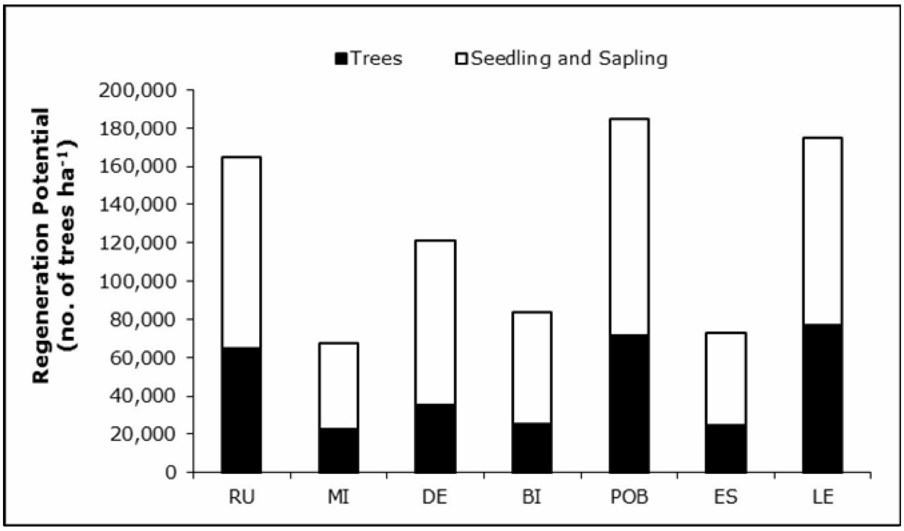

Figure 3. Comparison in regeneration potential of mangroves in Bacolod, Lanao del Norte. Legend: RU (Rupagan), MI (Minaulon), DE (Demologan), BI (Binuni), PO (Poblacion), ES (Esperanza) and LE (Liangan East).

Conclusions. Based from the result of this study, it can be concluded that the mangrove area in Bacolod is conducive to the growth of *Sonneratia alba*. It was mostly dominated by old stands of trees with large basal areas indicating that the area had minimal human disturbance. Moreover, the area has a high potential for mangrove regeneration due to its high relative number of saplings and seedlings. Subsequently, the number of saplings and seedlings are enough for the maintenance of the mangrove stand and the natural reforestation in some tidal areas. Thus, a continuous monitoring of mangroves in this area is recommended due to its function in the protection against coastal erosion and other ecological economic uses.

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