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Distribution and Autecology of Belimbing Merah (*Baccaurea angulata* Merr.) in Kalimantan

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Abstract. *Baccaurea angulata* is an underutilized plant, primarily grown for its fruit, which has potential as a medicinal plant. On the other hand very few studies have been carried out of this species. The purposes of this study were to analyze the *Baccaurea angulata* distribution and autecology. This study used purposive sampling method by exploring the area where *Baccaurea angulata* commonly found. The *Baccaurea angulata* distribution was analyzed using Morishita index, the autecological analysis with abiotic factor was performed using Principal Component Analysis (PCA) generated from Minitab 16 software. The distribution of *Baccaurea angulata* was random in West Kalimantan, East Kalimantan, and Central Kalimantan and clumped in South Kalimantan. Their distribution were affected by light intensity and humidity. This species grows well in low land (45-170 m above sea level) with soil pH 6-6.5.
Keywords: *Baccaurea angulata*, random distribution, light intensity, humidity

1. Introduction

Genus *Baccaurea* is a group of plants that produce fruit, but its existence is not as popular as other fruit plants. In addition to its fruit as fresh fruit and wood as a building material, members of genus *Baccaurea* have been used by localpeople as a medicinal plant to treat several diseases, among: constipation, swelling of the eyes, arthritis, abdominal pain, menstruation and urination [1-5]. *Baccaurea angulata* Merr. belongs to the family Phyllantaceae (previously under Euphorbiaceae) known locally as belimbing merah - belimbing darah, asam ketiak (Indonesia), belimbing hutan (Brunei), and tampoi hutan (Malaysia). This species is distributed and cultivated only in Borneo [1]. Belimbing merah can be distinguished from other species of *Baccaurea* base on its leaf and fruit characters: it has glabrous leaf upper and lower surface, dull to glossy dark green leaves when fresh, grey to green leaveas when dry, sometimes subglabrous at midrib,absent discoids gland, 9-16 secondary veins per side, cunneate to attenuate base, acumniate to cuspidate apex;obovoid fruit, star-shaped in cross section, red, purple, pink red to brown colour [6].

Phytochemical analysis has shown that belimbing merah fruit contains proteins, carbohydrates, fiber, minerals and vitamin C [7], vitamin A,E, and anthocyanin [8,9]. The juice Belimbing merah

fruit can also be used to prevent atherosclerosis, inhibit lipid peroxidase activity and induce antioxidant enzyme activity [10]. Fruitof belimbing merah is also a potential source of natural ingredients for cancer treatment [11], extract of belimbing merah fruit also has antimicrobial activity [12]. Belimbing merah fruit is also a potential source of antioxidants [9,10,13].

   Given the importance of belimbing merah as edible fruit and medicines that are potential to be developed for food and health, the research of distribution and autecology of belimbing merahhas been done. The aims of the research was to analyze the distribution and abiotic factors that affect of population existence of belimbing merah.

2. Study sites and methods

2.1. Study sites
This research was conducted from February to June 2017. Sampling was conducted in fourteen locations in Kalimantan, West Kalimantan (Sanggau, Entikong, Ngabang, Nangapinoh, Sompak, Sarumbi, Kembayan, Sambas and Sintang), East Kelimantan (Botanical Garden of Unmul Samarinda) South Kalimantan (Marajai and Barabai), Central Kalimantan (Pangkalan Bun and Muara Teweh). Analysis Ecological data is done in Ecology and Plant Resources Laboratory of Department of Biology FMIPA IPB.

2.2. Data collection
The data retrieval method was done by purposive sampling by visiting the location where possible the discovery of belimbing merah [14], based on information from local people. Then made a plot with size 20 x 20 m. The number of plots made in this research amounted to 39 plots. The data recorded in each plot is the number of individuals of belimbing merah, altitude, light intensity, humidity, temperature, soil moisture, soil pH. The equipment used during the observation were GPS 60 Garmin (altitude), Termohygrometer Haar-Synth-Hygro, Germany (air temperature and relative humidity), Soil tester TEW Type 36, Demetra, Japan (soil pH and relative humidity), Lux meter (light intensity).

2.3. Data analysis
Theobserved belimbing merah were from 14 locations in Kalimantan were analyzed using Morishitaindeks to identify its distribution patterns. the autecological analysis on abiotic factor was performed using Principal Component Analysis (PCA) generated from Minitab software version 16. The pattern of distribution of belimbing merah can be known based on Morishita indeks [15] :

$$I\delta = \ Q\ \frac{\sum_{i=1}^{q} Xi\ (Xi-1)}{T(T-1)}$$

Information:

Iδ = Indeks Morishita   To-i = (i=1,2,3....0

Xi = The number of individual X each plotQ   = Total plot

T = The total number of individual of a species per plot

If Iδ = 1 distribution pattern random, Iδ< 1 distribution pattern uniform, Iδ> 1 distribution pattern clumped

Degree of Uniformity (Iδ< 1)   Degree of grouping (Iδ>)

$$Mu\ =\ \frac{xi2\ 0{,}975-n+\sum xi}{\sum xi-i}$$ $$Mc\ =\ \frac{xi2\ 0{,}025-n+\sum xi}{\sum xi-i}$$

information:
X^2 0,975 = Value chi-square from the table with db (n-1), interval 97,5%
X^2 0,025 = Value chi-square from the table with db (n-1), interval 2,5%
$\sum X1$ = The total number of individu of species in plot i
n   = The number of plot standart Morishita degree

Standart Morishita degree (Ip):

If I$\delta \geq$ Mc > 1.0, then :   If 1.0 > Iδ> Mu, then :

$$Ip = 0{,}5 + 0{,}5 \frac{I\delta - Mc}{n - Mc}$$ $$Ip = -0{,}5 \frac{I\delta - 1}{Mu - 1}$$

If Mc >I$\delta \geq$ 1.0, then :   If 1.0 > Mu >Iδ, then :

$$Ip = 0{,}5 \frac{I\delta - 1}{Mc - 1}$$ $$Ip = -0{,}5 + 0{,}5 \frac{I\delta - 1}{Mu - 1}$$

Calculation of the Ipvalue will show the pattern of distribution of the dominant plant species in a community. The values and patterns of species distribution are as follows:
Ip = 0, Plant species have *random* distribution
Ip > 0, Plant species have *clumped* distribution
Ip < 0, Plant species have *uniform* distribution

3. Results

3.1. Distribution pattern of Baccaurea angulata
Morishitas indexs was a way to determine the spread of plant species in a habitat. Belimbing merah found in 9 locations in West Kalimantan Province, 1 location in East Kalimantan Province, 2 location in Central Kalimantan Province, 2 location in South Kalimantan Province. Based on Morishita indeks, it shows that most of belimbing merahindividuals spread randomly in the provinces of West Kalimantan, East Kalimantan, and Central Kalimantan, and it has clumpeddistribution in South Kalimantan (table 1). Morisita highest index value, amount to 0.0063 found on the location Sarumbi

Table 1. Distribution pattern of *Baccaurea angulata* in Kalimantan.

Location	Provinces	Distribution Indeks	Distribution Pattern
Entikong	West Kalimantan	0.0000	Random
Ngabang		0.0000	Random
Sarumbi		0.0063	Clumped
Kembayan		0.0000	Random
Sompak		0.0062	Clumped
Sanggau		0.0000	Random
Nangapinoh		0.0000	Random
Sintang		0.0000	Random
Sambas		0.0000	Random
Samarinda	East Kalimantan	0.0000	Random
Muara Teweh	Central Kalimantan	0.0000	Random
Pangkalan Bun		0.0000	Random
Marajai	South Kalimantan	0.00032	Clumped
Barabai		0.00006	Clumped

3.2. Suitable abiotic factors for Baccaurea angulata
Environmetal factors (altitude, humidity, temperatur, light intensity, soil moisture and soil pH) were measured in each location (table 2). In general, environmental factors have a high variation, such as

altitude ranges between 45-148 asl. In West Kalimantan provinces, belimbing merah was found in location with temperatures are higher than in other provinces. Belimbing merah found in Samarinda, East Kalimantan, has the most different ecological conditions from other locations that has low temperature and low light intensity, but it has highest humidity. It located only at an altitude of 68 m asl, the plant. Growsin the Botanical Garden of Unmul Samarinda (KRUS) which still has preserved vegetation.In the province of Central Borneo belimbing merahwas found at different elevations 75 and 80 m altitude, and they have different microclimate. In South Kalimantan provinces found in location with soil pH range between 6.4-6.5 are higher than in other provinces.

Table 2. Microclimate around *Baccaurea angulata* locations.

Locations	Microclimate					
	Altitude (m asl)	Humidity (RH%)	Temperature (^{o}C)	Light Intensity (Lux)	Soil Moisture (RH %)	Soil pH
Entikong	94	74-78	30-32	1870-2260	70-72	6-6.3
Ngabang	73	75-81	27-32	2645-3110	69-71	6-6.2
Sarumbi	79	80	30-31.5	1330-1450	72	6
Kembayan	45	70	32	2650	71	6.4
Sompak	118	80	30	1587	70	6.5
Sanggau	148	79	32	2600	79	6.3
Nangapinoh	135	79	32	2228	77	6
Sintang	129	80	28-31	1120-1880	72-74	6.3-6.4
Sambas	70	79	32	3207	77	6
Samarinda	68	90	23-28.3	877-890	80	6.4
Muara Teweh	75	82	30	1890-2034	75	6.5
Pangkalan Bun	80	79	28.7-30	1906-1990	76	6.3
Marajai	144	80	28-30	1337-1680	75-82	6.4-6.5
Barabai	92	79	29	2260	79	6.5

Based on Principal Component Analysis (PCA), belimbing merah plants were clustered according to the origin of the population and some of belimbing merah plants blend or falls outside of the ecological factors specific populations (figure 1A). Light intensity and humidity factors have a great influence on the presence of belimbing merah population (figure 1B). The existence of belimbing merah plants at location of Entikong, Ngabang, Nangapinoh, Marajai Sompak, Sanggau influenced by light intensity and humidity.

4. Discussion
Our result showed that belimbing merah have different distribution randomly and clumped. The results of this study are not relevant to the Barbour *et al*. statement [16] which states that the distribution pattern of plants tends to be clump, due to seeds of seeded that fall near its mother or rhizomes that produce vegetative seedlings are still close to their mother. The pattern of random distribution found in several locations in Kalimantan region due to reduction where belimbing merah grow. Decreasing the habitat belimbing merahoccurs because the forest is converted to oil palm and rubber plantations. Distribution pattern is also influenced by micro-climate at each observed location of belimbing merah plants. The pattern of distribution is controlled by several processes such as environmental heterogeneity [17-19].

Belimbing merah has faound in each location have different altitude.However, this difference still in accordance with a previous study [1] that reported that the belimbing merah is one of Borneo endemic fruit plant found in primary and secondary forest, on sandy soil or laterite with 0-800 m asl altitude.Changing altitude somewhere causes a change in the microclimate of the place such as the intensity of light, temperature and humidity [20-22]. Meanwhile in South Kalimantan,belimbing

merah found at an altitude from 92 to 144 m asl, has clumped distribution. This pattern is allegedly related to environmental factors (microclimate) belimbing merah habitat.
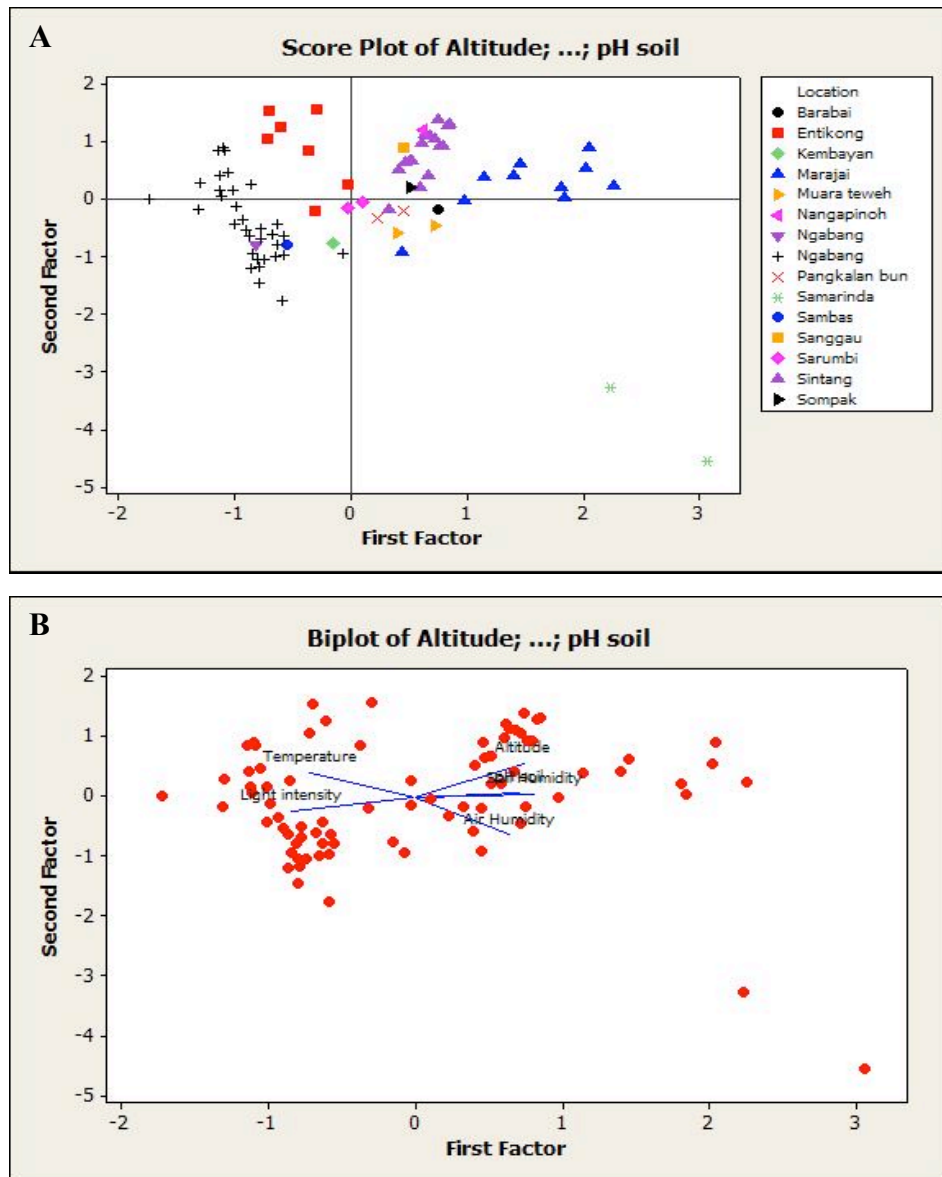

Figure 1. A. Distribution of belimbing merah; B. Correlation of environmental factors to the distribution of belimbing merah.

In general, the air temperature is inversely proportional to the humidity around the observation location. The correlations indicates that when the temperature rises, the humidity decreases. Humidity was related to the rate of photosynthesis in plants.Temperature variability in each location of observation is also due to the differences of altitude and vegetation surrounding belimbing merah. The differences in canopy characters also affect the temperature differences [23]. Belimbing merah is found in altitude of 45-140 m asl with soil pH ranged from 6-6.5. Our result showed that Humidityand light intensityhaveimportant role in the presence of belimbing merah. Several factors also play an important role in the distribution of tree species in tropical forests such as nutrient content, soil chemical elements, acidity (pH) of soil, rocks and topography [24,25].

5. Conclusion

Belimbing merah (*Baccaurea angulata* Merr.) was randomly distributed in the provinces of West Kalimantan, East Kalimantan, Central Kalimantan and clumped distributed in provinces South Kalimantan. Two abiotic factors affected the distribution of belimbing merahare the light intensity, 877 - 3110 lux, and humidity, 74 - 90%. Belimbing merah plants grow well at an altitude of 45-170 m asl with soil pH 6-6.5.

Acknowledgements

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