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MORPHOLOGICAL VARIATION
AND NEW VARIETY OF
BACCAUREA ANGULATA MERR.
(PHYLLANTHACEAE)

by . Gunawan

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DISTRIBUTION, MORPHOLOGICAL VARIATION AND NEW VARIETY OF *BACCAUREA ANGULATA* MERR. (PHYLLANTHACEAE)

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Gunawan, Tatik Chikmawati, Sobir & Sulistijorini. 2018. Distribusi, Variasi Morfologi dan Varietas Baru dari *Baccaurea angulata* Merr. (Phyllanthaceae). *Floribunda* 6(1): 1–11. — *Baccaurea angulata* (belimbing merah) adalah jenis endemik di Kalimantan yang dimanfaatkan sebagai bahan pangan dan obat tradisional, namun sejauh ini informasi distribusi dan variasinya masih sangat terbatas. Penelitian ini bertujuan memetakan lokasi-lokasi tumbuh pohon *B. angulata*, menggambarkan variasi morfologi, dan analisis fenetik *B. angulata* yang tumbuh di Kalimantan dan Pulau Natuna. Eksplorasi *B. angulata* dilakukan di Pulau Natuna dan empat provinsi di Kalimantan (Barat, Timur, Tengah dan Selatan). Peta persebaran dibuat dengan program ArcGIS versi 10.3. Pola distribusi dianalisis menggunakan indeks Morishita. Data morfologi batang, daun, bunga, dan buah digunakan untuk analisis fenetik belimbing merah berdasarkan koefisien *Simple Matching* (SM) dengan metode UPGMA. *B. angulata* tersebar secara acak di Kalimantan Barat, Tengah dan Pulau Natuna, tetapi memiliki pola penyebaran mengelompok di Kalimantan Selatan dan Timur. Penemuan *B. angulata* di desa Ceruk dan Limau Manis di Pulau Natuna dengan nama lokal belimbing besi merupakan rekaman baru. Peta sebaran *B. angulata* di Kalimantan dan Pulau Natuna disediakan. Secara morfologi, *B. angulata* di Kalimantan dan Pulau Natuna bervariasi pada beberapa ciri yaitu tepi stipula, permukaan tangkai daun, warna tangkai perbungaan betina, dan bentuk buah. Analisis fenetik mengelompokkan seluruh sampel ke dalam tiga kelompok *B. angulata* berdasarkan 20 ciri morfologi dengan nilai keserupaan 53% sesuai dengan bentuk dan rasa buah. *B. angulata* dengan buah membulat diusulkan sebagai varietas baru dengan nama *B. angulata* Merr. var. *globulus* Gunawan.

Kata kunci: *Baccaurea angulata*, Kalimantan, Pulau Natuna, rekaman baru, varietas baru, *Phyllanthaceae*.

Gunawan, Tatik Chikmawati, Sobir & Sulistijorini. 2018. Distribution, Morphological Variation and New Variety of *Baccaurea angulata* Merr. (Phyllanthaceae). *Floribunda* 6(1): 1–11. — *Baccaurea angulata* (belimbing merah) is an endemic species of Borneo. Fruits of *Baccaurea angulata* are usually utilized as food and local medicine, but up to now the information about its distribution and variation is very scarce. The objectives of the research were to map the distribution, describe the morphological variation, and analyze the phenetics of *B. angulata* in Natuna Island and Indonesian Borneo, Kalimantan. *B. angulata* was explored in Natuna Island and four Provinces of Kalimantan (West, East, Central, and South). The distribution was mapped using ArcGIS version 10.3. The distribution pattern was analyzed using the Morishita index. Morphological data of stem, leaves, flower and fruit were used to analyze the phenetics of *B. angulata* using Simple Matching coefficient, to construct a dendrogram using UPGMA method. *B. angulata* is randomly distributed in the West and Central of Kalimantan, also in Natuna, but it has a clumped pattern in South and East Kalimantan. The presence of *B. angulata* in the Ceruk and Limau Manis villages in Natuna Island with local name belimbing besi is a new record. *B. angulata* is morphologically variable in several characters, i.e. stipule margin, petiole surface, pistillate peduncle colour, and fruit shape. Phenetic analysis based on 20 characters grouped all individuals into three groups with similarity index of 53% according to the shape and fruit taste. The individuals of *B. angulata* with oval fruits are proposed to constitute a new variety, namely *B. angulata* Merr. var. *globulus* Gunawan.

Key words: *Baccaurea angulata*, Kalimantan, Natuna Island, new record, new variety, *Phyllanthaceae*.

Baccaurea angulata Merr. (belimbing merah; *Phyllanthaceae*) was first published by Merrill in 1929. This species has many different local names, for example: asam ketiak, pidau, umbing and umbung (Kalimantan, Borneo); embaling bobou, belimbing hutan (Brunei); embaling, belimbing uchong, pelawak, popotong, tampoi hutan, and liposu (Sabah); uchong, ujung, belimbing bukit, belimbing dayak, belimbing hutan, belimbing merah, tampoi belimbing (Sarawak) (Haegens 2000; Lim 2012).

B. angulata is considered to have less economic value when compared to its relatives such as rambai (*B. motleyana*). Fortunately, it is a species used as a food source and it has the potential to develop into a medicinal plant in the future. This plant produces a red fruit with star fruit-like shape. The edible part of this fruit is its pericarp and aril with sweet to acidic flavour. *B. angulata* is found in primary and secondary forests between 0–800 m asl (Haegens 2000). The increasing conversion of forest into palm oil and rubber plantations negatively affects the *B. angulata* populations by reducing its natural habitat.

Phytochemical analysis of the fruit peel of *B. angulata* has shown that it contains protein, carbohydrates, fibers, minerals and vitamin C (Voon & Kueh 1999), vitamin ¹⁶, E and anthocyanin compounds (Ahmed *et al.* 2014; Norazlan Shah *et al.* 2015). Mikail *et al.* (2014; 2015) reported that *B. angulata* juice can be used to prevent athero-sclerosis, inhibit lipid peroxidase activity and induce antioxidant enzyme activity. *B. angulata* also has the potency to be a source of natural ingredients for cancer treatment (Adam & Bahar 2015), an antioxidant (Ibrahim *et al.* 2013; Lim 2012), and to have anti microbial activity (Momand *et al.* 2014).

Previous studies (Haegens 2000; Uji 2004, 2007; Lim 2012) reported that the distribution of *B. angulata* is only in Borneo, where it is an endemic species. Up to now, no publication reported the presence of *B. angulata* outside Borneo. The information on morphological variation within this species is also very limited. Then, the information on the existence of a plant in a place and its variations is useful for data collection of plant populations, recording the diversity of flora and its habitat, also its development for further uses (Lestari 2014; Djuita *et al.* 2016). This study aimed to provide distribution information, and analysis the

morphological variation within *B. angulata*.

METHODS

Exploration of *B. angulata*

The exploration and sample collection of *B. angulata* was carried out in Indonesian Borneo, Kalimantan and Natuna Island based on information from the forestry service and the local communities. The explored areas were 15 districts and cities in Kalimantan and Natuna Islands. The explored areas in West Kalimantan included Entikong, Ngabang, Sarumbi, Kembayan, Sompak, Sanggau, Nangapinoh, Sintang and Sambas. In East Kalimantan, Samarinda was explored. In Central Kalimantan, Muara Teweh and Pangkalan were visited. Marajai and Barabai were explored in South Kalimantan. In Natuna Islands Northeast Bunguran was sampled.

Distribution Mapping, Morphological Character Observation and Data Analysis

The distribution of *B. angulata* was mapped using ArcGIS version 10.3. based on the coordinates of the collecting point of the collections made during the exploration with GPS 60 Garmin, label information in 14 specimens of Herbarium Bogoriense (BO), 5 specimens of Herbarium Wana-riset (WAN), and 20 specimens images from Herbarium Leiden (L). The distribution pattern was analyzed using Morishita index (Ip) (Morishita 1959). The values and patterns of species distribution are as follows: Ip = 0; random distribution, which individuals spread in several places and cluster elsewhere. Ip > 0; clumped distribution, where individuals always be in groups and so rarely to be separated. Ip < 0; uniform distribution, which individuals are located in a specific place within the community (Michael 1994).

A total of 98 *B. angulata* trees were observed for their morphological characters, which included qualitative and quantitative traits of stems, leaves, flowers and fruits (Table 1). The botanical terms used are based on Harris & Harris (2006) and Rifai & Puryadi (2008). The character measurements are arranged in a data matrix and used for phenetic analysis¹² based on Simple Matching (SM) coefficient and Unweighted Pair-Group Method Arithmetic Average (UPGMA) method. All analyzes were performed using NTSys ver 2.11a program (Rohlf 2004).

Table 1. Characters and traits used in the phenetic analysis of *B. angulata*

No	Characters	Traits (score)	
1	Crown shape	0 = conical 2 = rounded	1 = pyramidal
2	Crown width (m)	0 = 1.58–2.5 2 = 3.25–4.5	1 = 2.5–3.25
3	Bark colour	0 = bright brown 2 = greyish brown	1 = greyish green 3 = dark brown
4	Stem diameter (cm)	0 = 0.23–0.43 2 = 0.61–0.74	1 = 0.43–0.61
5	Texture of bark	0 = smooth	1 = rough
6	Petiole surface	0 = glabrous	1 = sparsely hairy
7	Petiole length (cm)	0 = 3.5–5.5 2 = > 10	1 = 5.6–10
8	Leaf length (cm)	0 = 7.2–10 2 = 20–30	1 = 10–20 4 = > 30
9	Leaf width (cm)	0 = 3.1–5 2 = > 10	1 = 5–10
10	Leaf shape	0 = ovate 2 = obovate	1 = elliptic
11	Leaf apex	0 = acuminate 2 = round	1 = acute
12	Leaf base	0 = acuminate 2 = round	1 = acute
13	Indumentum of leaf venation	0 = glabrous	1 = sparsely hairy
14	Number of secondary vein	0 = <10	1 = >10
15	Stipule length (mm)	0 = 3–5 2 = > 10	1 = 5–10
16	Leaf length and width ratio	0 = 2–3	1 = 3.01–4.11
17	Stipule margin indumentum	0 = glabrous	1 = hairy
18	Outer surface of stipule	0 = glabrous	1 = sparsely hairy
19	Fruit shape	0 = pentagonal to hexagonal -shaped in cross section	1 = round-shaped in cross section
20	Colour of inflorescence peduncle	0 = red	1 = green

RESULTS AND DISCUSSION

Distribution of *B. angulata* in Indonesian Borneo and Natuna Island

Based on data collected from specimens at Herbarium Bogoriense, Herbarium Wanariset and as well as exploration sites, *B. angulata* is distributed through out Kalimantan. *B. angulata* also distributed in Malaysia and Brunei (Haegens 2000). Some of the specimens collected before the

year of 2000, which show some locations of *B. angulata* plants, have under gone changes, especially in the East Kalimantan location, Tanah Merah subdistrict. This is due to the alteration of forest area into oil palm and rubber plantations. Environmental damage, such as landfires that often occur in Kalimantan also influence to the distribution of *B. angulata* plants, can decrease the totally of trees. Ouinsavi & Sokpon (2010) mentioned that climate change and environmental

degradation can affect vegetation form and species distribution.

During the exploration of *B. angulata*, 98 trees were found. Sixty seven individuals were collected from primary and secondary forests, 5 individuals in a house yard, 23 individuals in the forest-edge and 3 individuals in the roadside. Local people utilize the fruit and harvest it directly from the forest and sell in the markets as fresh fruit. Based on the information from the local community, until now there no effort has been made to propagate *B. angulata*, although they know that it has economic benefits. Previous studies have reported that the distribution of *B. angulata* is only in Borneo. However, based on our exploration, *B. angulata* is also found in Ceruk village and Limau Manis village, North East Bunguran Sub-district, Natuna Island, which is a new record.

In Natuna Island, *B. angulata* grows in secondary forest. Compared to trees from Kalimantan, *B. angulata* from Natuna Island has shorter trees and the leaf blades are narrower and smaller. These differences are likely due to the ecological and environmental differences in which they grows. Based on exploration, the average air humidity and the temperature of *B. angulata* locations in Natuna Island are 86% and 22–33.3°C, respectively, which are higher compared to that of the *B. angulata* place in Indonesian Borneo with an average air humidity of 80% and temperature 23–32 °C. In addition, the average soil pH in Natuna Island is 6 which is lower than that of Indonesian Borneo, 6.3. The distribution of the *B. angulata* in Kalimantan is presented in Figure 1, and the distribution of the *B. angulata* n Natuna Island is presented in Figure 2.

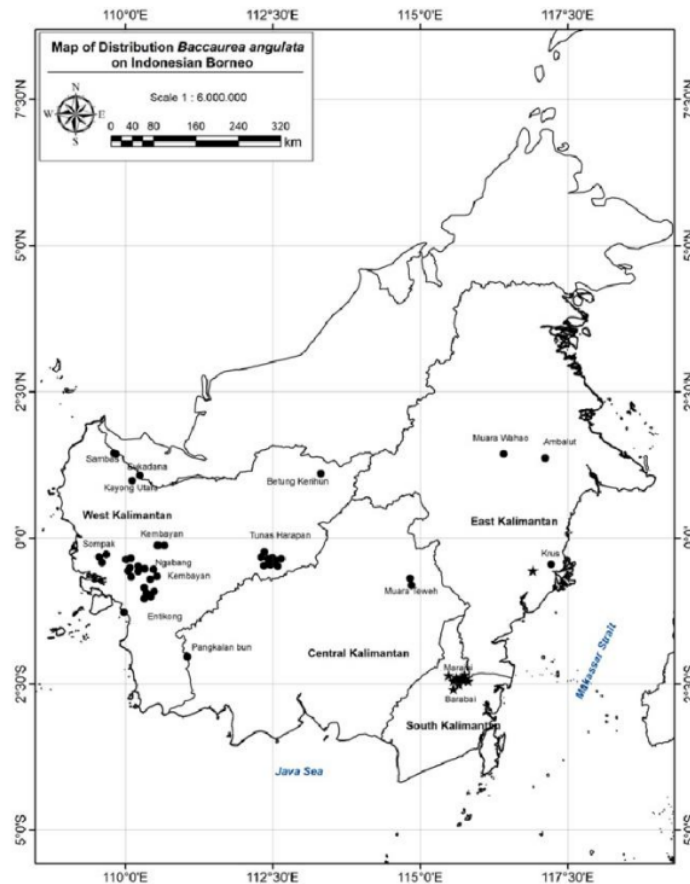


Figure 1. Distribution of *B. angulata* in Indonesian Borneo, Kalimantan. □ obovoid and pentagonal to hexagonal-shaped fruits, *: obovoid and round-shaped fruits.

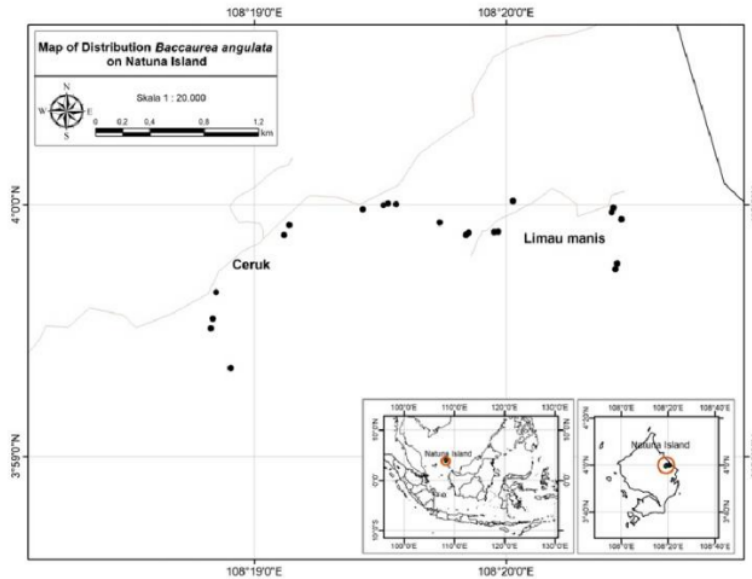


Figure 2. Distribution of *B. angulata* in Natuna Island.

The local distribution of *B. angulata* shows variation distribution patterns (Table 2). Most specimens are spread randomly in West Kalimantan, East Kalimantan, Central Kalimantan and in Natuna Island. However, in South Kalimantan a clumped pattern is found. This results is in agreement with Barbour *et al.* (1987) which stated that the pattern of distribution of seed plants tends to be clumped, because their seeds tend to fall near the

parental tree. Based on observation, the pattern of random distribution that was found in several locations in the region of Kalimantan is caused by decreasing the natural habitat of *B. angulata*. Then, the decreasing of natural habitat can be caused by conversion of forest into oil palm and rubber plantation. In the other case, the pattern of distribution can also be influenced by the microclimate of the location where *B. angulata* grows.

Table 2. Distribution pattern of *B. angulata* in Kalimantan and Natuna Island

Province	Locations	Distribution Index	Distribution Pattern
West Kalimantan	Entikong	0.0000	Random
	Ngabang	0.0012	Clumped
	Sarumbi	0.0063	Clumped
	Kembayan	0.0000	Random
	Sompak	0.0062	Clumped
	Sanggau	0.0000	Random
	Nangapinoh	0.0000	Random
	Sintang	0.0000	Random
East Kalimantan	Sambas	0.0000	Random
	Samarinda	0.0024	Clumped
Central Kalimantan	Muara Teweh	0.0000	Random
	Pangkalanbun	0.0000	Random
South Kalimantan	Marajai	0.00032	Clumped
	Barabai	0.00006	Clumped
Riau	Natuna	0.0029	Random

Morphological Variation of *B. angulata*

B. angulata varied on some morphological characters such as the stipule margin, petiole surface, colour of the inflorescence peduncle, and the fruit shape. The stipule margin is ciliate or

glabrous (Figure 3). The petiole surface is glabrous or minutely hairy (Figure 4). The colour of the pistillate inflorescence peduncle is red or green (Figure 5). The fruit is either obovoid with a round shape or pentagonal to hexagonal (Figure 6).

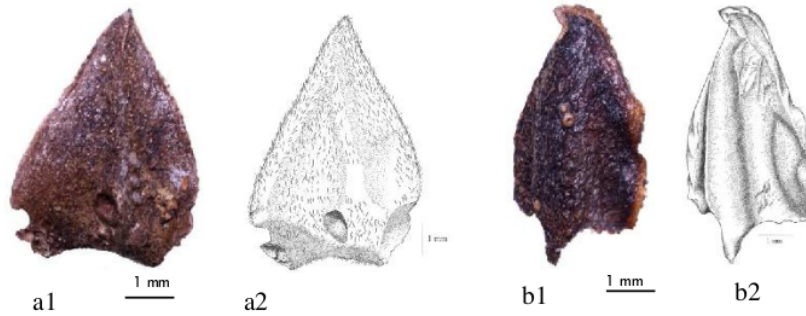


Figure 3. Variation of the stipule margin, a1 & a2: ciliate margin, b1 & b2: glabrous margin. 1: photo, 2: drawing.

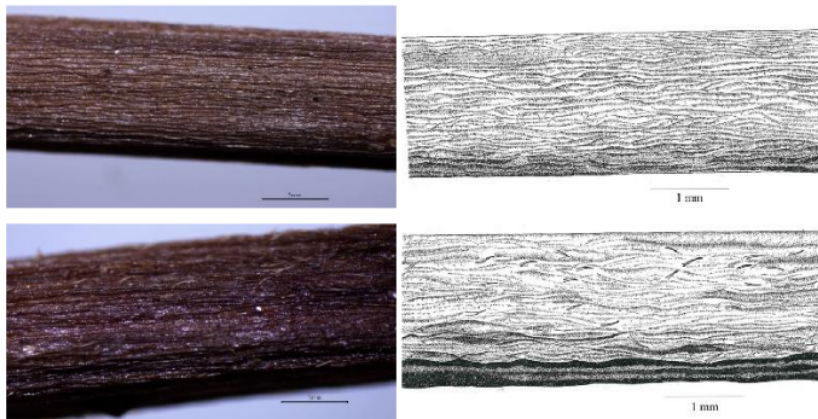


Figure 4. Variation of the petiole surface, a1 & a2: glabrous, b1 & b2: sparsely hairy. 1: photo, 2: drawing



Figure 5. Variation in the colour of the pistillate inflorescence peduncle, a: red, b: green.



Figure 6. Variation in fruit shape, a: obovoid and round-shaped cross section of fruit with an acuminate tip; b: obovoid and hexagonal-shaped cross section of fruit with an acute tip.

Fruit length is 3.5–6.7 cm, diameter 2.8–4.5 cm. Seeds are 1.56–1.9 cm long, and width 1.1–1.23 cm. The different fruit shapes do not affect shape and size of the seeds. The fruits that are round in transverse section and that have an acuminate tip are not included in the species description of *B. angulata* by Merrill (1929) and Haegens (2000). This shape is mainly concentrated in South Kalimantan (Fig. 1) in group I in the dendrogram (Fig. 7) and regarded here to constitute a new variety under the name *B. angulata* Merr. var. *globulus*.

The fruits of *B. angulata* in Natuna Island have the same colour and star shape as *B. angulata* from Indonesian Borneo, but they are smaller. The characteristics of *B. angulata* in Natuna Island: Trees, is 8–11.5 m tall, 12–16.5 cm in diam, bark dark brown, densely hairy outside and ciliate along margin; petiole 3.5–6.5 cm long, glabrous; leaf blade oblong to ovoid, 2.3–26.5 by 4.4–6.5 cm, completely glabrous, upper surface shiny dark green lower surface pale green; inflorescences 5–13.6 cm long, green, 34–50 flowered, pedicels 1.45–2 mm long, densely hairy; flowers 1.04–2.1 mm in diam, sepals 4 or 5, obovate, densely hairy; angled fruits, 3.5–4.8 by 2.8–4 cm, red; 1–3 seeded, seeds 1.1–1.3 by 0.8–1.1 cm; wide; aril white.

Phenetic Analysis of *B. angulata*

The cluster analysis of 98 individuals was on 20 morphological characters. The resulting dendrogram showed three major groups (Figure 7).

In similarity coefficient of 53%, all individuals were divided into three major groups. Group I consists of 12 individuals collected in South Kalimantan: Marajai (MRJ1, MRJ2, MRJ3, MRJ4, MRJ5, MRJ6, MRJ7, MRJ8, MRJ9, MRJ10,

MRJ11, MRJ12). Group I is grouped based on similarity of 7 characters: bark bright brown-coloured, crown slightly rounded, stipula with outside minutely-hairy, petiole minutely hairy, midrib minutely hairy below, peduncle of pistillate inflorescence red and fruit round-shaped in cross section. This group comprises the new variety.

Group II consists of eight individuals South Kalimantan: Barabai (BRB); West Kalimantan: Entikong (ENT2) and Sintang (SI7); Central Kalimantan: Muara Teweh (MTW1), and Natuna Island (NTA2, NTA3, NTA13, NTA17). All individuals in group II have similarity in 7 characters: of bark grayish-brown, crown conical, stipule glabrous, petiole glabrous, midrib glabrous, peduncle of pistillate inflorescence green and fruit pentagonal to hexagonal-shaped in cross section.

Group III consists of 77 individuals of *B. angulata* originating from West Kalimantan: Entikong (ENT1, ENT6, ENT3, ENT4, ENT5) Sarumbi (SAR1, SAR2, SAR3, SAR4), Ngabang (NGA1 to NGA21), Kembayan (KMB), Sintang (SIN1 through SIN17), Sanggau (SAG), Nangapinoh (NGP1, NGP2); East Kalimantan: Samarinda (SMR1, SMR2, SMR3); Central Kalimantan: Pangkalan Bun (PKB), Muara Teweh (MTW2); Natuna (NTA1, NTA4, NTA8, NTA6, NTA7, NTA8, NTA9, NTA10, NTA11, NTA18, NTA19, NTA20, NTA21, NTA22, NTA23, NTA24, NTA25). Group III is characterized: bark dark brown, crown pyramidal, stipule hairy, petiole glabrous, midrib glabrous, peduncle of pistillate inflorescence green and fruit pentagonal to hexagonal-shaped in cross section.

The morphological similarities of each group is not related to the origin of each individual. Specimens from South Kalimantan (Marajai) are only scattered into group I, except individuals from

Barabai. Then, other specimens from West Kalimantan (Entikong, Sarumbi, Ngabang, Kembayan, Kapuas Sintang, Sanggau, Nangapinoh, and Samarinda), East Kalimantan (Samarinda), and Central

Kalimantan (Muara Teweh and Pangkalanbun) are distributed into group II and III. Specimens from Natuna Island, also spread into groups II and III.

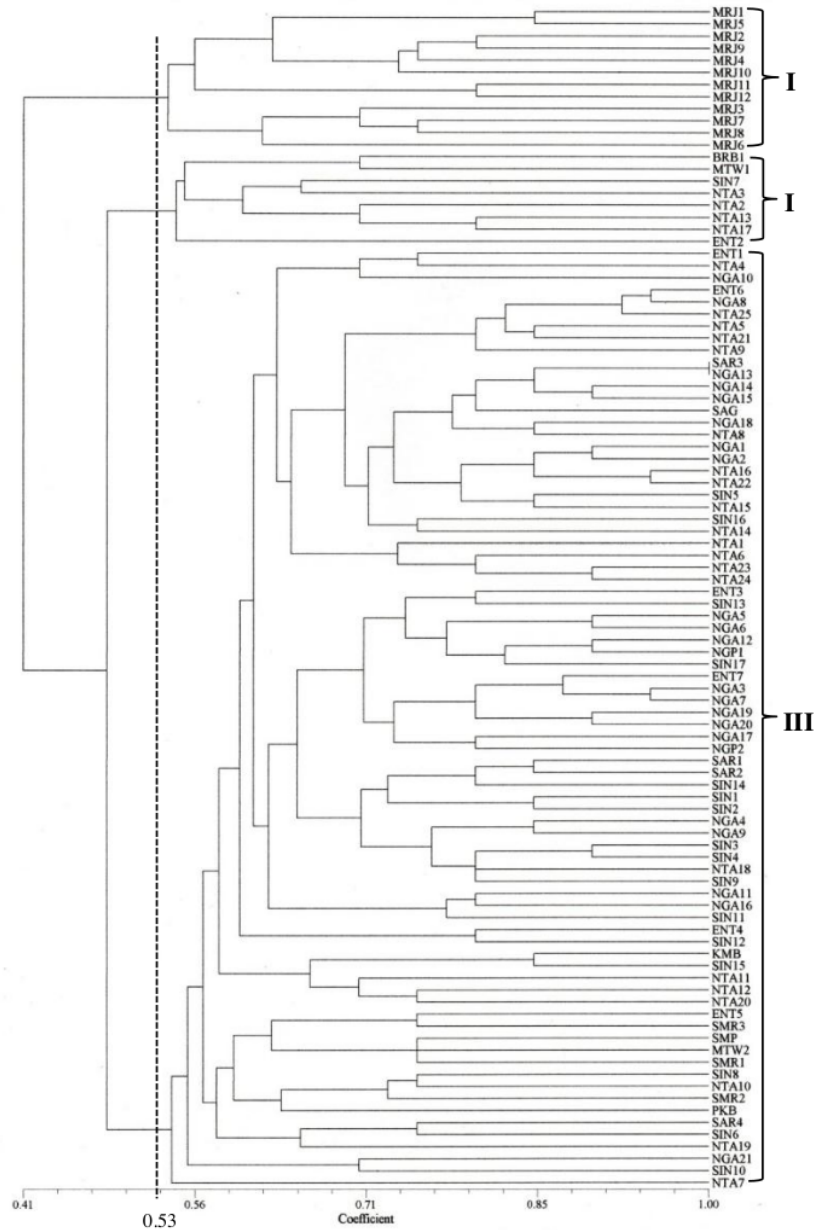


Figure 7. Dendrogram of *B. angulata* grouping based on 20 morphological characters using simple matching coefficient and UPGMA method. ENT. Entikong, NGA. Ngabang, SAR. Sarumbi, KMB. Kembayan, SMP. Sompak, SAG. Sanggau, NGP. Nangapinoh, SIN. Sintang, SBS. Sambas, SMR. Samarinda, MTW. Muara Teweh, PKB. Pangkalan Bun, MRJ. Marajai, BRB. Barabai, NTA. Natuna.

Taxonomic Treatment

B. angulata Merr.

B. angulata Merr., Univ. Calif. Publ. Bot. 15 (1929) 148; Meyer, Bot. News Bull. Forest Dept., Sabah 7 (1967) 35; Airy Shaw, Kew Bull, Addit. Ser. 4 (1975) 46; Haegens, Blumea (2000) 12. Type: Elmer 2/542 (holo A; iso B, DS, G, L, U), Borneo, Sabah, Tawau.

Tree 5.5–22 m high, 9.6–40 cm in diameter; branchlets glabrous; young shoots pale straw when fresh. Terminal branching pattern weakly developed. Buttresses absent. Bark soft to hard, flaky, bright brown, grey-brown to red-brown to green, 9.6–40 cm in diameter; inner bark yellow to reddish to green, 0.6–4 mm thick. Stipules glabrous to densely hairy outside, glabrous inside, margin ciliate, 4.2–11 mm. Leaves simple, alternate; blade elliptic to obovate, 12–40 cm, length/width ratio 2.2–3.6:1; base cuneate to attenuate (rounded); margin entire; apex acuminate to cuspidate to rarely obtuse; upper surface glabrous, dull to glossy dark green when fresh; lower surface glabrous, sometimes subglabrous at midrib; secondary veins 9–16 per side, closed at margin; venation reticulate, not distinct; petiole 2–12.5 mm

long, cylindrical, glabrous. Staminate inflorescences cauline, green, 0.5–26 cm long, flowers distributed along inflorescence up to 51 flower, sparsely hairy, 3 flowers per node. Staminate flowers yellow, 2–2.8 mm in diam., pedicel 2–4 mm long, sepals 4 or 5, obovate 1–1.5 mm long, apex slightly recurved, outside and inside densely hairy; stamens 6, 0.5–0.7 mm long, glabrous; anthers 0.5–0.6 by 0.1–0.3 mm, pistillode c.0.4 mm high, densely hairy, hollow. Pistillate inflorescences, green to red, solitary or up to 7 clustered together, 3.8–26 cm long, subglabrous to densely hairy. Pistillate flowers 4–9 mm in diam., sepals 5 or 6, elliptic, 8–9 mm long, outside and inside densely hairy; ovary urn-shaped, 3–5 mm long, 3-locular, densely hairy, wings 0–6; style absent; stigmas 0.6–1.4 mm long, glabrous to subglabrous above, glabrous to densely hairy below. Fruits obovoid, round to star-shaped in transverse section, 1–3-seeded, 3.5–6.7 cm fruit long, 2.8–4.5 cm in diam., base acute-acuminate, red to purple to pink to red-brown, petiole 4–8 mm long, pericarp 1–2 mm thick. Seeds globose to ellipsoid, laterally flattened, 1.56–1.9 by 1.1–1.23 cm, testa bright brown. Arillode white, 2.1–4.23 mm thick; sweet to sweet-sour in flavour.

Identification key to the varieties

1. a. Leaf blades c. 2.2 times longer than wide. Pistillate inflorescence peduncle green to red. Fruit star-shaped in transverse section, apex acute..... var. *angulata*
- b. Leaf blades 2.7–3.6 times longer than wide. Pistillate inflorescence peduncle red. Fruit round in transverse section, apex acuminate.....var. *globulus*

a. var. *angulata*

Bark grey-brown to red-brown to green when fresh; crown conical to pyramidal. Petiole glabrous; stipules glabrous to densely hairy outside; leaf blades 12–39 by 4–13.6 cm, 2.2 times longer than wide; sometimes subglabrous at midrib. Peduncle of pistillate inflorescence green to red; fruits obovoid, star-shaped in cross section; apex acute.

Specimens examined. Indonesia, Borneo, West Kalimantan, Kayong Utara, 23 Maret 2010, Hery Yanto, Endri Setiawan, Adi Bejo, Edi 1906001 (BO); Indonesia, Borneo, West Kalimantan, Betung Karihun National Park, 23 Februari 2000, Sidiyasa K 1368339 (BO); Indonesia, Borneo, West Kalimantan, Ngabang, 23 Februari 2017, Gunawan 012; Indonesia, Borneo, East Kalimantan, Manubar, 16 Juli 1951, A. Kostermans 1476896 (BO); Indonesia, Borneo, East Kalimantan, Kayu Mahakam, 16 km from Ambalut, 18 July

1976, K. Kartawinata 1894543 (BO); Indonesia, Borneo, East Kalimantan, Kayu Mahakam, 16 km from Ambalut, 18 July 1976, K. Kartawinata 1894544 (BO); Indonesia, Borneo, East Kalimantan, Samarinda-Kurs, Kebun Raya Unmul, 11 Mei 2017, Gunawan 050; Indonesia, Borneo, Center Kalimantan, Muara Teweh, 20 Juni 2017, Gunawan 063–064; Indonesia, Natuna, Limau Manis; 26 Mei 2017, Gunawan 066–070; Indonesia, Natuna, Ceruk 28 Mei 2017, Gunawan 071–076.

Distribution: Borneo; Natuna

Habitat and Ecology: Primary and secondary rain forest, altitude 40–800 m asl

b. var. *globulus* Gunawan, var. nov.– Fig. 8.

– Type: Indonesia, Borneo, Kalimantan Timur, Tanah Merah, Lempake, 10 Km from Samarinda, 6 Januari 1977, K. Kartawinata 1441 (BO).

Bark bright brown; crown slightly rounded; stipula with outside minutely hairy, petiole minute-

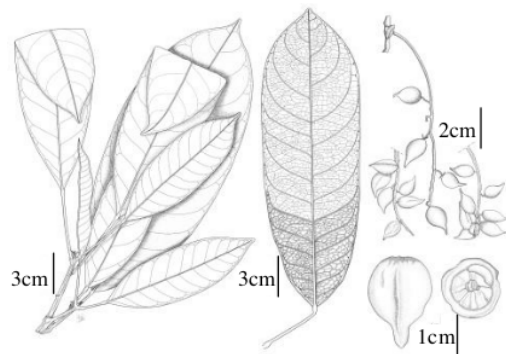


Fig. 8. *B. angulata* Merr. var. *globulus* Gunawan, var. nov. (K. Kartawinata 1441, Gunawan 082).

ly hairy, midrib minutely hairy below, leaf blades 22.5–40 by 8.5–11 cm, 2.7–3.6 times longer than wide; peduncle of pistillate inflorescence red; fruit obovoid, round-shaped in transverse section; apex acuminate.

Ecology and habitat: primary forest, altitude 144–675 m asl.

Distribution: East and South Kalimantan.

Local name: si lulung.

Utilization: fruit eaten, fruit peel also used as vegetables.

Specimens examined. Indonesia, Borneo, West Kalimantan, Tanah Merah, Lempake, 10 Km from Samarinda, 6 January 1977, K. Kartawinata 1441 (BO); Borneo, East Kalimantan, Kutai Timur, Muara Wahau, PT. Narkata Rimba, 13 December 2009, Arifin Z & Suharja I, 0926349 (WAN); Borneo, South Kalimantan, Balangan, Marajai, 6 June 2016, Gunawan 082.

Local people commonly harvest fruits of *B. angulata* from the forest (Siregar 2005). In West Kalimantan, fruits of *B. angulata* are sold as fresh fruit or processed as a spice (sour-spicy spice) (Subekti *et al.* 2005). In Central Kalimantan, local people use the fruit as a fermented beverage. In South Kalimantan and Natuna Island, fruits of *B. angulata* are found in many traditional markets during the fruit season. In addition, the stem can be used as building materials and furniture (Lim 2012). In general, *B. angulata* blooms from July to September (Haegens 2000), and October to November will be in fruiting season. Based on observations, at the time of exploration and description of the local people, the flowering season of *B. angulata* almost coincide with durian.

CONCLUSION

B. angulata was found to be distributed not only in Kalimantan but also in Natuna Island, with the local name belimbing besi, which has the same characteristics as *B. angulata* that grows in Kalimantan. The morphological variations of *B. angulata* consisted of stipule margin, petiole surface, the color of pistillate inflorescence peduncle, and the shape of the fruit. Variants with round-shaped in transverse section and apex acuminate are proposed to be a new variety named *B. angulata* var. *globulus*. It have been found only in East and South Kalimantan. Based on the morphological characteristics, *B. angulata* trees were divided into 3 groups with similarity coefficient of 53%. Group I consisted of *B. angulata* with rounded-shape and sweet flavor, group II is hexagonally-shaped fruit with sour flavor, and group III is group of *B. angulata* with hexagonally-shaped fruit and sweet-sour flavor.

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REFERENCES

- Adam M & Bahar MS. 2015. Expression of Matrix Metalloproteinase-13 in Human Skin Melanoma Cancer Treated by *Baccaurea angulata* in vitro. *Journal of Basic and Applied Research* 1 (1): 21–28.
- Ahmed IA, Mikail MA, Ibrahim M, Hazali N, Rasad MSBA, Gani RA, Wahab RA, Arief SJ & Yahya MNA. 2014. Antioxidant activity and phenolic profile of various morphological parts of underutilized *Baccaurea angulata* fruit. *Food Chemistry*.doi: <http://dx.doi.org/10.1016/j.foodchem.2014.09.122>
- Barbour MG, Burk JH & Pitts WD. 1987. *Terrestrial Plant Ecology (2nd ed.)*. CA: The Benjamin/Cummings Publishing Company, Inc.
- Djuita NR, Hartana A, Chikmawati T & Dorly.

2016. Distribusi Kapulasan (*Nephelium Ramboutan-Ake* (Labill.) Leenh.) di Pulau Jawa dan Kekerabatan Morfologinya. *Floribunda* 5(4):129–164
- Haegens R. 2000. Taxonomy, phylogeny, and biogeography of *Baccaurea*, *Distichirhops*, and *Nothobaccaurea* (Euphorbiaceae). *Blumea Supplement* 12.
- Harris JG & Harris MW. 2006. *Plant Identification Terminology. An Illustration Glossary*. Utah (US): Spring Like Publishing.
- Ibrahim D, Hazali N, Jauhari N, Omar MN, Yahya MNA, Ahmed IA, Mikail MA & Ibrahim M. 2013. Physicochemical and antioxidant characteristics of *Baccaurea angulata* fruit juice extract. *African Journal of Biotechnology* 12(34): 5333–5338.
- Lestari R. 2014. Morphological Variation and Species Distribution of *Baccaurea dulcis* (Jack) Mull. Arg. in West Java, Indonesia. *International Journal of Biology* 6(1):17–28
- Lim TK. 2012. *Edible Medicine and Non-Medicine Plants: Volume 4*. London New York. Springer.
- Merrill ED. 1929. *Plantae Elmerianae Borneenses. Univ. Calif. Bot.* 15: 145–153.
- Mikail MA, Ahmed IA, Ibrahim M, Hazali N, Rasad MSBA, Ghani RA, Wahab RA, Arief SJ, Isa MLM, Draman S, Ishola AA & Yahya MNA. 2014. Changes in The Markers of Atherosclerosis Following Administration of Belimbing Dayak (*Baccaurea angulata*) Fruit Juice in Experimental Rabbits Fed With Cholesterol Diet. *International Journal of Advances in Agricultural & Environmental Engg (IJAAEE)* Vol. 1. <http://dx.doi.org/10.15242/IJAAEE.C614516>.
- Mikail MA, Ahmed IA, Ibrahim M, Hazali N, Rasad MSBA, Ghani RA, Hashim R, Wahab RA, Arief SJ, Isa MLM, Draman S & Yahya MNA. 2015. *Baccaurea angulata* fruit inhibits lipid peroxidation and induces the increase in antioxidant enzyme activities. *European Journal Nutrition*. DOI 10.1007/s00394-015-0961-7.
- Michael PE. 1994. *Metode Ekologi untuk Penyelidikan Ladang dan Laboratorium*. Universitas Indonesia. Jakarta.
- Momand L, Zakaria R, Ibrahim M, Mikail M, Jalal T & Wahab A. 2014. Antimicrobial effect of *Baccaurea angulata* fruits extracts against human pathogenic microorganisms. *Medical & Aromatic Plants* V. 3(4):1–5. <http://dx.doi.org/10.4172/2167-0412.1000172>.
- Morishita M. 1959. *Measuring of The Dispersion on Individuals and Analysis of the Distributional Patterns*. Kyushu University. Japan
- Norazlan Shah, Afiq M, Muhammad & Masri M. 2015. Determination of phytochemicals and vitamin content of under utilized *Baccaurea angulata* fruit. *Journal Pharmacognosy and Phytochemistry* 4(4): 192–196.
- Ouinsavi C & Sokpon N. 2010. Morphological variation and ecological structure of Iroko (*Milicia excelsa* Welw CC Berg) population across different biogeographical zones in Benin. *International Journal of Forestry Research*, 1, 1–11. <http://dx.doi.org/10.1155/2010/658396>.
- Rifai MA & Puryadi D. 2008. *Glosarium Biologi*. Jakarta (ID). Pusat Bahasa Departemen Pendidikan Nasional.
- Rohlf FJ. 2004. *NTSystpc. Numerical Taxonomy and Multivariate Analysis System. User Guide*. Department of Ecology and Evolution. State University of New York. New York [US]: Exeter Software.
- Siregar M. 2005. Review: Species diversity of local fruit trees in Kalimantan: Problem of conservation and its development. *Biodiversitas* 7(1): 94–99.
- Subekti A, Yeni S, Sumaryadi T, Anggraito B & Ibrahim TM. 2005. Penggalan Data Pendukung Domestikasi dan Komersialisasi Jenis, Spesies, dan Varietas Tanaman Buah di Kalimantan Barat. *Prosiding Lokakarya I Domestikasi & Komersialisasi Tanaman Hortikultura*. Puslitbang Hortikultura, Balitbang Pertanian, Departemen Pertanian. Jakarta. 23–34.
- Uji T. 2004. Keanekaragaman Jenis, Plasma Nutrafah, dan Potensi Buah-buahan Asli Kalimantan. *BioSmart* 6(2): 117–125.
- Uji T. 2007. Review: Keanekaragaman Jenis Buah-Buahan Asli Indonesia dan Potensinya. *Biodiversitas* 8(2): 157–167.
- Voon BH & Kueh HS. 1999. The nutritional value of indigenous fruits and vegetables in Sarawak. *Asia Pacific. Journal of Clinical Nutrition* 8: 24–31.

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