

# *Baccaurea* Lour. (Phyllanthaceae Martinov-Malpighiales), underutilized plant from Riau, Indonesia and its phytochemical study

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**Abstract.** Sofiyanti N, Fitmawati, Isda MN, Agesti ARA, Sari M, Pranata S. 2022. *Baccaurea* Lour. (Phyllanthaceae Martinov-Malpighiales), underutilized plant from Riau, Indonesia and its phytochemical study. *Biodiversitas* 23: 937-946. *Baccaurea* (Phyllanthaceae) is one of underutilized plants in Riau Province, Indonesia. Our finding in some districts shows the variation of morphological characters of *Baccaurea* members. However, there is no detailed morphological study of these genera reported from this province. This study aimed to identify *Baccaurea* species from Riau and characterized their morphology, as well as, phytochemical contents. The specimens were collected from the field, documented and observed in detail their morphological characters. Phytochemical screening had been conducted using qualitative tests of a total of six secondary metabolites (alkaloid, terpenoid, steroid, tannin, flavonoid and saponin). A total of seven *Baccaurea* species were identified in this study. The main characteristic that can be used to distinguish each species are leaf characteristics (venation, size and shape), floral pattern and fruit characters. The phytochemical contents vary among the examined *Baccaurea*. Steroid and tannin are absent from all of examined specimens. Terpenoid is commonly found in all fruit parts of all specimens. The result of this study provides the first detailed morphological record as well as phytochemical data of *Baccaurea* from Riau.

**Keywords:** *Baccaurea*, morphology, phytochemistry, rambai, tampui

## INTRODUCTION

*Baccaurea* Lour. is a genus in Phyllanthaceae. This family is a segregate of Euphorbiaceae sensu lato, together with four other families, i.e. Euphorbiaceae sensu stricto, Pandaceae, Picrodendraceae and Putranjivaceae (Hoffman et al. 2006). The terminology of *Baccaurea* genus was based on fruit characteristic (*bacca* – Italian word that means berry, a simple fruit that produced from single ovary). *Baccaurea* was firstly placed in Euphorbiaceae (Lour 1790). The members of this genus are characterized by having tree habit, cauliflorous flower (Gunawan et al. 2021) borne mainly as clustered spike (or racemes), sub-rounded to rounded fruit with sour to sweet juicy arillode (Sivadasan et al. 2020). A total of 173 *Baccaurea* species had been published (Summarized from Lour 1790; Shu et al. 2008; Gunawan et al. 2016; Khoo et al. 2016; Erwin et al. 2018; Gunawan et al. 2018; Nanik et al. 2019; Sivadasan et al. 2020; Charu et al. 2021). However, 87 out of 173 species are considered as synonyms (GBIF, POWO, theplantlist.org). The members of *Baccaurea* are distributed in southeast Asia, India (Sivadasan et al. 2020; Charu et al. 2021), Bhutan, Cambodia, Laos, Myanmar, Nepal, China, Vietnam; Pacific islands, China, New Guinea (Shu et al. 2008), Thailand (Manik et al. 2019; Prodhon et al. 2021), Malaysia (Bakar et al. 2014; Kho et al. 2016; Khadijah et al. 2018ab), Indonesia (Akhmadi and Sumarmiyati 2015; Gunawan et al. 2016, 2018; Erwin et al. 2018; Gunawan et al. 2021ab). Some of species of this

genus are listed in IUCN red list, as vulnerable (*B. costulata*, *B. glabrifolia*, *B. odoratissima*, *B. purpurea*) and endangered (*B. carinata*). However, many of *Baccaurea* species are wild and considered as indigenous and underutilized species (Khadijah et al. 2018b; Halim et al. 2019). Therefore, the information of their biological aspect as well as their potencies are lack and little known.

The literature review on *Baccaurea*, revealed that some species of this genus had been used traditionally by local people to treat various diseases in South Asia (Charu et al. 2021) due to their pharmacological properties. The studies by Falah and Hadiwibowo (2017), Zamzani and Triasditi (2019), Shivadasan et al. (2020) and Charu et al. (2021), reported that the pharmacological properties of plant are caused by the presence of phytochemical contents. These contents are secondary metabolites produced by plant, e.g. alkaloid, triterpenoid, steroid, saponin and tannin. The studies on phytochemical contents of *Baccaurea* had been reported on *B. macrocarpa* (Bakar et al. 2014; Erwin et al. 2018; Salusu et al. 2020; Charu et al. 2021), *B. motleyana* (Halim et al. 2019), *B. lanceolata* (Bakar et al. 2014; Salusu et al. 2020; Charu et al. 2021), *B. courtallensis*, *B. ramiflora*, and *B. angulata* (Charu et al. 2021). In their studies, bark and leaves were the common part that had been used than fruit.

The members of *Baccaurea* in Indonesia had been recorded from Sumatera, Kalimantan, Java, Bali, Sulawesi, Nusa Tenggara and Papua Island. However, the highest number of *Baccaurea* species is found in Kalimantan.

Therefore, the studies on this genus were mostly reported from this area (Akhmadi and Sumarmiyati 2015; Gunawan et al. 2016; Erwin et al. 2018; Gunawan et al. 2018; Nanik et al. 2019; Salusu et al. 2020; Sumarni et al. 2020; Gunawan et al. 2021). The occurrence of *Baccaurea* species in Sumatera had been recorded from Aceh (Yusuf 2011), West Sumatera (Hariyanto and Bismark 2014; Ramayani et al. 2017), Jambi (Nuraida and Sari 2019), Bengkulu Island (Riau) (Ramayani and Fitmawati 2020). However, only little known study on biological aspect of *Baccaurea* from Sumatera Island, Indonesia especially in Riau Province. The only study on *Baccaurea* from Riau was reported by Ramayani and Fitmawati (2020), which examined the morphological diversity of *B. montleyana* (Rambai). Our survey on 2020 in Riau, indicated the interesting finding on the morphological variation of *Baccaurea*. This study aims to provide the first record of this underutilized *Baccaurea* species from Riau. Furthermore, the phytochemical study of *Baccaurea* fruit parts were also examined to screen the secondary metabolite.

## MATERIALS AND METHODS

### Study area

This study had been conducted from March to September 2021. The specimens were collected in the field, with the assistance of local guide. Figure 1 shows the study site of this study.

### Sample collection

Samples were collected from the field using purposive sampling method. The sample locations were informed by local guide or local fruit sellers. The vegetative and generative parts were photographed and labeled based on the location and name of species. The herbarium specimens were deposited in Herbarium Riauensis.

### Morphological characterization and brix level

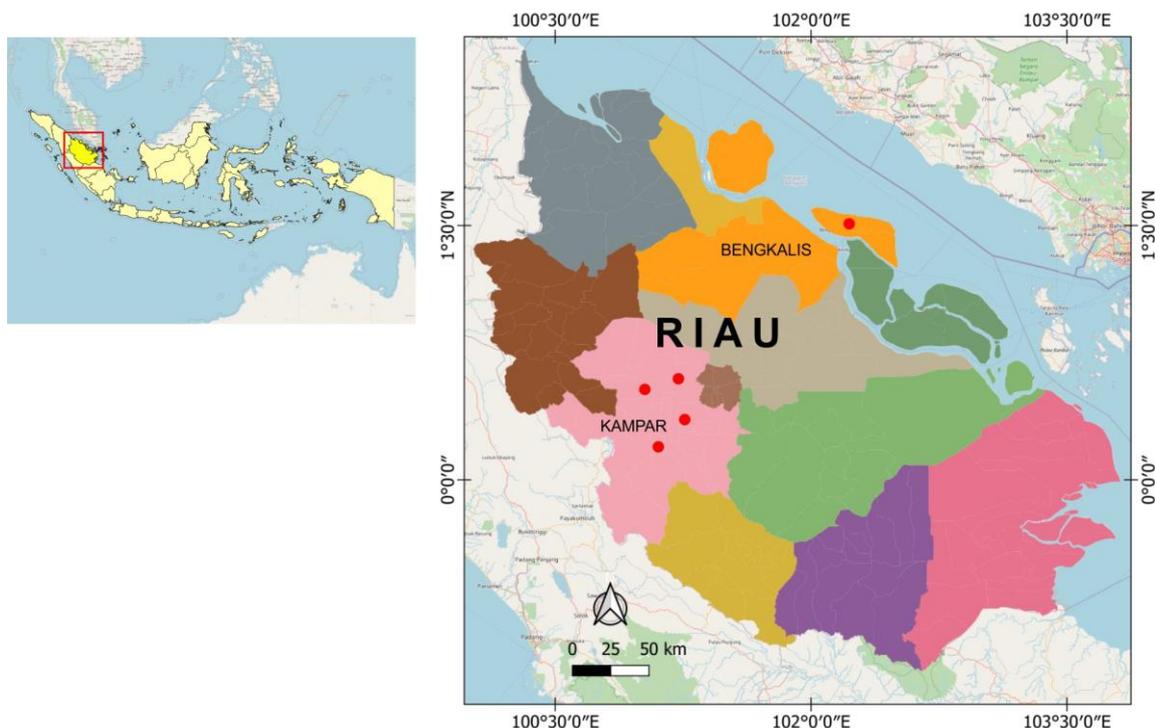
All of the collected specimens were examined in detail to provide morphological character descriptions. The Brix level of aril was measured using Brix Refractometer to examine the level of sugar content.

### Identification of the species

The identification was carried out based on the morphological characters of collected specimens. The herbarium specimens from virtual herbarium were also examined for the related taxa. We also use online identification by using this following website: [www.gbif.org](http://www.gbif.org), [www.plantsoftheworldonline.org/](http://www.plantsoftheworldonline.org/), [www.worldfloraonline.org/](http://www.worldfloraonline.org/), [identify.plantnet.org/](http://identify.plantnet.org/).

### Phytochemical study

The phytochemical study had been carried out on three different part of *Baccaurea* fruit, i.e. pericarp, aril and seed. Each fruit parts were separated manually and were then ground using herbal Grinder to prepare fresh extract. The methods to investigate six secondary metabolites are presented below (based on Sangi et al. 2008; Deepa et al. 2014; Raman et al. 2018; Sofiyanti et al. 2021).



**Figure 1.** Location of specimens collected from Riau Province, Indonesia (indicated by red dot) (map source : petatematikindo)

### Alkaloids

A total of 4 g of ground sample, chloroform, and 10 mL ammoniac-chloroform were mixed and filtered. As many as 10 filtrate drops were mixed with H<sub>2</sub>SO<sub>4</sub> 2N, mix well. 3 drops of upper layer were then mixed with Dragendorff solution. The presence of alkaloid is indicated by red to orange precipitation.

### Steroids and terpenoids

These secondary metabolites were tested together by making a mixture of 50 mg of ground sample and AAG. Incubate the mixture for 15 min. Add 3 drops H<sub>2</sub>SO<sub>4</sub>. The presence of steroid was indicated by green to blue coloration, while triterpenoid was indicated by orange to purple coloration.

### Flavonoids

Mix well a total of 200 g ground sample with 5 mL 70% ethanol and heat for 5 min before adding 3 drops of absolute HCl and 0.2 mg powder. The presence of yellow, orange to dark red or magenta coloration indicated the positive content of flavonoid.

### Saponin

Mix 2 g of ground sample with aquades, boiled 2-3 min, then shake the mixture strongly. Saponin was indicated by the presence of soapy foaming substance.

### Tannin

Mix 20 mg thin cut sample with 70% ethanol. Take 1 mL mixture and add 2 drops of 1% FeCl<sub>3</sub>. The bluish dark green coloration indicated the positive content of tannin.

### Data analysis

The result of phytochemical study was presented using symbol + (positive) and – (negative). The data were then tabulated and descriptively analyzed.

## RESULTS AND DISCUSSION

### The species

In this study, we examined a total of 31 individuals of *Baccaurea* that belong to seven *Baccaurea* species. Table 2 shows the list of examined *Baccaurea* species from Riau Province, Indonesia. Figure 2 presents the morphology of *Baccaurea* identified in this study, while Figure 3 present the quantitative data of *Baccaurea* fruits and their brix level.

### Species enumeration

#### *Baccaurea deflexa* Müll.Arg, Prodr. 15, 2 (1866) 462

Description: Tree. Leaves: petiole 55-65 mm long, hairy; lamina papery, ovate, 20-23 cm long by 7.2-9.3 cm wide, ratio of length and wide 1.9-2.5, base acute, margin entire, apex acuminate (8-11 long), upper surface glabrous; secondary veins ca. 12 pairs, alternate, tip connected with upper secondary vein. Fruit globose, 32-35 mm long by 32-34 mm wide, rounded at the base, tip almost acute; pericarp densely hairy outside, other part of pericarp reddish dark

brown at maturity, inner part reddish-brown; 3-(or 4)-seeded fleshy capsule, aril glossy, orangish-red, placenta whitish light brown; seed globose, laterally flattened, 9-11 x 8-10 mm.

Synonym: none.

Vernacular name: Tungau, Tampui Merah (Riau)

Examined specimens: BATUNG1, BATUNG2, Kampar, Riau Province, collector Maya.

Other examined specimens (virtual herbarium or online specimen in GBIF): *B. deflexa*, Herbarium of The Forest Department Sandakan, SAN 141026; *B. deflexa*, Herbarium Leiden, L 0050885, L 0162723; *B. deflexa*, Herbarium Museum Paris, P 05472261; *B. deflexa*, Herbarium UNAND, ANDA 00035311, ANDA 00035312; *B. deflexa*, New York Botanical Garden, NY Barcode: 03932932, 39329333, 932934, 3932935, 3932936, 3932938, 3932939

Uses: arillode edible, sour to sweet.

Distribution: Peninsular Malaysia, Sumatra, Borneo.

Note: *B. deflexa* is rarely found in Riau. The fruit is sold in local market or roadside in Kampar District, in a bundle, the fruit price ranges from Rp. 20.000 to 25.000 per kg. The local name “Tungau” represents red mite, while “Tampui Merah” due to its reddish dark brown pericarp and reddish brown aril (Merah is red in Indonesian language). Figure 3 presents the histogram of weight of fruit, pericarp and aril, as well as brix level of aril. Based on this figure, *B. deflexa* shows the second lighter fruit and pericarp after *B. motleyana*. However, its aril weight (7.63 g) is heavier than *B. motleyana*, *Baccaurea* sp.2 and *Baccaurea* sp.3. In this study, we examined the Brix level of aril (Figure 3), which had been developed by Adolf Brix in the mid 1880s (Kleinhenz and Bumgarner 2012). Usually, the measurement of Brix level (Degree Brix) is used to know the quality of fruit that correlated to the number of soluble solids (Harril 1998), and the most abundant soluble solid in fruit juice is sugar (Kleinhenz and Bumgarner 2012). The degree Brix (°Brix) 50 means that in 100 ml fruit juice contains 50 g of sugar and other soluble solids. Therefore, it is also presented as total soluble solid (TSS) (as reported by Khadijah et al. 2018). In this study, the mean of the Brix level of *B. deflexa* is 25.20° Brix (Figure 3) (or 25.20 % TSS).

#### *Baccaurea edulis* Merr. Calif. Publ. Bot. 15 (1929) 149

Description: Tree. Leaves: petiole 65-75 mm long, hairy; lamina papery, ovate, 17-29 cm long by 7-12 cm wide, ratio of length and wide 1.7-2.8, base acute, margin entire, apex acuminate (4-6 long), upper surface glabrous; secondary veins ca. 17, alternate, curve upward and ending close at the margin. Fruit globose, rounded at the base, apex shortly acute, 45-62 mm by 43-61 mm, loculicidal, clearly grooved toward base; groove 3; pericarp glabrous outside, reddish brown at maturity, ca. 8-11 mm thick; 3-(or 4)-seeded fleshy capsule, arillode bright yellow, sweet, glossy and smooth to wavy, placenta white; seed globose, laterally flattened 11-13 by 9-27 mm.

Synonym: None

Vernacular name: Tampui, Tampui Kuning (Riau)

Examined specimens: BAKUN1, BA KUN2, Kampar, Riau Province, collector Maya; BAKUN3 Rumbio, Kampar, Riau Province, Collector Nery.

Other examined specimens (virtual herbarium or online specimen in GBIF):

*B. edulis* (Type), Sweden's Virtual Herbarium, Cat. S07-14710; *B. edulis*, Kew Herbarium, K001056495; *B. edulis*, Herbarium of The Forest Department Sandakan, SAN 142722, SAN 134904; *B. edulis*, United State National Herbarium, 3140492; *B. edulis*, Rijksherbarium Leiden, L 162691; *B. edulis*, Herbarium Monacense, M 0233640 (Isotypus).

Uses: arillode edible, sweet.

Distribution: Peninsular Malaysia, Sumatra, Borneo.

Note: *B. edulis* is rarely found in Riau. We only found it in Rumbio and Kuansing district. The fruit of this species is sold in local market and road site. However, the seller usually mixed with the fruit of *B. macrocarpa*, and sold in the same bundle because they consider these species is the same Tampui. The fruit price is range from Rp. 20.000 to 35.000 per kg. *B. edulis* is locally known as tampui or Tampui Kuning (Kuning is Indonesian word, means yellow), due to its yellow aril. We observed two different fruit characteristics of this species, especially in fruit tip and aril characteristics. However, the mean of degree Brix of aril is similar (ca. 27.20 °Brix) (Figure 3).

***Baccaurea macrocarpa* (Miq.) Müll.Arg. Prodr. 15, 2 (1866) 457**

Description: Tree. Leaves: petiole 80-95 mm long, hairy; lamina papery, ecliptic to obovate, 19-37 cm by 9.5-18 cm, ratio of length and wide 2.0-3.5, base acute almost rounded, margin entire, apex acuminate (10-15 long), upper surface glabrous; secondary veins ca. 6 pairs, alternate, ending open at margin. Fruit almost globose, 4-6.5 cm by 5-8.1 cm, rounded at the base, narrower toward apex, locucidally, clearly grooved toward base; groove 3; pericarp (sub) glabrous outside, light brown at maturity, ca. 12-16 mm thick, light brown; pedicle 15-2 mm long, thickened at abscission zone; 6-seeded fleshy capsule, arillode glossy white, milky white to yellowish white, placenta white and clearly present at the upper part of aril; seed 10-13 x 12-15 mm, light brown, ecliptic shape, laterally flattened.

Synonym: *Baccaurea borneensis* (Müll.Arg.) Müll.Arg.; *Baccaurea griffithii* Hook.f.; *Mappa borneensis* Müll.Arg.; *Pierardia macrocarpa* Miq.

Vernacular name: Tampui, Tampui Premium (Riau)

Examined specimens: BATA1, BATA2, Kampar Kiri, Collector Maya; BATA3, Kuntu, collector Rony; BATA4, BATA5, BATA6, Rimbau Panjang, Bangkinang, Kampar, Riau Province, collector Nery.

**Table 2.** List of examined *Baccaurea* from Riau, Indonesia

Species	Vernacular name in Riau	Sample code
<i>Baccaurea deflexa</i> Müll.Arg	Tungau, Tampui Merah	BATUNG1*
<i>Baccaurea deflexa</i> Müll.Arg	Tungau, Tampui Merah	BATUNG2*
<i>Baccaurea edulis</i> Merr.	Tampui, Tampui Kuning	BAKUN1*
<i>Baccaurea edulis</i> Merr.	Tampui Kuning	BAKUN2*
<i>Baccaurea edulis</i> Merr.	Tampui Kuning	BAKUN3
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA1*
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA2*
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA3*
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA4
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA5
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA6
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui	BATA7
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui Premium	BAPRE1*
<i>Baccaurea macrocarpa</i> (Miq.) Müll.Arg.	Tampui Premium	BAPRE2
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM1*
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM2*
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM3*
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM4
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM5
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM6
<i>Baccaurea motleyana</i> (Müll.Arg.) Müll.Arg	Rambai	BARAM3
<i>Baccaurea</i> sp.1.	Tampui Kecil	BATAM1*
<i>Baccaurea</i> sp.1.	Tampui Kecil	BATAM2*
<i>Baccaurea</i> sp.1.	Tampui Kecil	BATAM3
<i>Baccaurea</i> sp.2.	Tampui Merah	BAME1*
<i>Baccaurea</i> sp.2.	Tampui Merah	BAME2*
<i>Baccaurea</i> sp.2.	Tampui Merah	BAME3
<i>Baccaurea</i> sp.3	Onggang	BAONG1*
<i>Baccaurea</i> sp.3	Onggang	BAONG2*
<i>Baccaurea</i> sp.3	Onggang	BAONG3

Note: \*samples for phytochemical study and Brix level test

Other examined specimens (virtual herbarium or online specimen in GBIF): *B. macrocarpa*, Kew Herbarium: 64440.000, K001056444, K001056443 and K001056445; *B. macrocarpa*, New York Botanical Garden, NY Barcode: 44458, 03932965, 3932967, 3932968, 3932969, 3932970, 3932971; *B. macrocarpa*, Herbarium Universitas Andalas, ANDA 00035315; *B. macrocarpa*, Rijksherbarium Leiden, L 2188785, L 0163693, L 0447331.

Uses: arillode edible, sweet.

Distribution: India, Peninsular Malaysia, Sumatra, Borneo.

Note: the local name of *B. macrocarpa* varies among the provinces of Indonesia, such as Tampui Rimba in Jambi Province (Nuraida and Sari, 2021), Tampoi in Kalimantan (Tirtania et al. 2013) or Aceh (Navia et al. 2019), Kapul in Kalimantan (Norhayati et al. 2019) and South Sumatera Province (Salusu et al. 2020), Kapul Putih (Madiyahati et al. 2017) in Kalimantan. During the fruit season, *B. macrocarpa* fruit is more commonly found than other wild *Baccaurea* species in Riau. Usually, the fruits are sold in a bundle or pile (Rp. 25.000–35.000 per kg). In this study we observed two different fruit size, and local fruit sellers distinguished them as Tampui and Tampui Premium. Tampui is the local name for the smaller fruit (ca. 5,0 cm in diameter, with fruit weight ca. 53.5 g). While Tampui Premium has bigger fruit (ca. 8.1 cm in diameter) and the heaviest fruit among the *Baccaurea* in this study (ca. 103.20 g). The degree Brix is almost similar, 26.90°Brix for Tampui and 27.40°Brix for Tampui Premium. Both fruits have sweet aril taste.

### ***Baccaurea motleyana* (Müll.Arg.) Müll.Arg**

Description: Tree. Leaves: petiole 45–60 mm long, hairy; lamina papery, ecliptic to obovate, 26–36 cm by 12–15 cm, ratio of length and wide 2.0–2.5, almost rounded at the base, margin entire, apex acuminate (13–17 mm long), upper surface glabrous; secondary veins ca. 14 pairs, alternate, ending open at margin. Fruit ellipsoid, 25–40 x 18–24 mm, rounded at the base, narrower toward apex; pericarp hairy outside, light brown at maturity, ca. 1–2 mm thick, light brown; 3-seeded fleshy capsule, arillode translucent white to white, placenta white; seed 8–10 x 5–7 mm, light brown, ecliptic shape, laterally flattened. Pedicel 15–20 mm long, thickened at abscission zone.

Synonym: *Baccaurea pubescens* Pax & K.Hoffm.; *Pierardia motleyana* Müll.Arg.

Vernacular name: Rambai (Riau)

Examined specimens: BARAM1, BARAM2, Bengkalis Island, Riau Province; BARAM3, BARAM4, BARAM5, BARAM6, Bangkinang, Kampar, Riau Province, collector Nery.

Other examined specimens (virtual herbarium or online specimen in GBIF): *B. motleyana*, Kew Herbarium, K001056522 (Holo), K001056529; *B. motleyana*, New York Botanical Garden, NY Barcode: 03932977, 03932898; Herbarium Universitas Andalas, ANDA 10339, ANDA 10331, ANDA 10333, ANDA 10335; *B. motleyana*, Rijksherbarium Leiden L 219673.

Uses: arillode edible, sour to sweet.

Distribution: Indonesia (Sumatera, Borneo and Halmahera); Malaysia (Sivadasan et al. 2020)

Note: *B. motleyana* is also well known as Rambai in Malaysia (Sivadasan et al. 2020). However, this local name is also used *B. lanceolata* in East Kalimantan (Falah and Hadiwiboyo 2017). In Riau, *B. motleyana* is commonly cultivated by local people in home garden than other *Baccaurea* species. However, many of these trees are still found as wild fruit tree in the forest. During the fruit season, the fruits are sold in local market the price is Rp. 15.000–20.000 per kg. Figure 3 shows that quantitative data of *B. motleyana* fruit is the lowest the other species in this study, as well as brix level of aril (19.8 °Brix).

### ***Baccaurea sp1***

Description: Tree. Leaves: petiole 45–50 mm long, hairy; lamina papery, ecliptic to obovate, 9–11 cm by 4–6 cm, ratio of length and wide 2.0–2.5, almost rounded at the base, margin entire, apex acuminate (ca. 2–3 mm long), upper surface glabrous; secondary veins ca. 7 pairs, alternate, tip open at the margin at the base, close toward apex. Fruit globose, 45–50 x 42–46 mm, rounded at the base, apex almost flat; pedicel 8–9 mm long, thickened at abscission zone; pericarp glabrous outside, dull redish brown at maturity, ca. 6–7 mm thick, translucent light brown; 4-seeded fleshy capsule, arillode translucent white, placenta white; seed 11–12 x 10–11 mm, light brown, globose, laterally flattened.

Vernacular name: Tampui Kecil (Riau)

Examined specimens: BATAM1, BATAM2, BATAM3, Bangkinang, Kampar, Riau Province, collector Nery.

Uses: arillode edible, sour to sweet

Note: This species is locally called Tampui Kecil due to its smaller fruit size than Tampui (*B. macrocarpa*). However, the fruit of species has no clear groove at the base, as we observed on *B. macrocarpa*. Furthermore, *Baccaurea sp1* is characterized by having open tip of secondary vein, glossy outer pericarp and flattened to slightly curved fruit tip, with unclear placenta at the top of aril. These characters are very different of those in fruits of *B. macrocarpa*. Further study is needed to determine the taxonomic status of *Baccaurea sp*.

### ***Baccaurea sp2***

Description: Tree. Leaves: petiole 45–60 mm long, hairy; lamina papery, ecliptic to obovate, 11–15 cm by 4.5–8 cm, ratio of length and wide 2.0–2.5, base almost rounded, margin entire, apex acuminate (13–17 long), upper surface glabrous; secondary veins ca. 14 pairs, alternate, ending open at margin. Fruit almost globose, 35–40 x 30–34 mm, almost flat at the base, narrower toward apex; pericarp (sub) glabrous outside, dull red, ca. 6–9 mm thick, light brown; 3 – (to 6) seeded fleshy capsule, arillode translucent white to white, placenta white; seed 10–11 x 5–6 mm, light brown, oblong, laterally flattened. Pedicel 9–10 mm long, thickened at abscission zone.

Vernacular name: Tampui Merah (Riau)

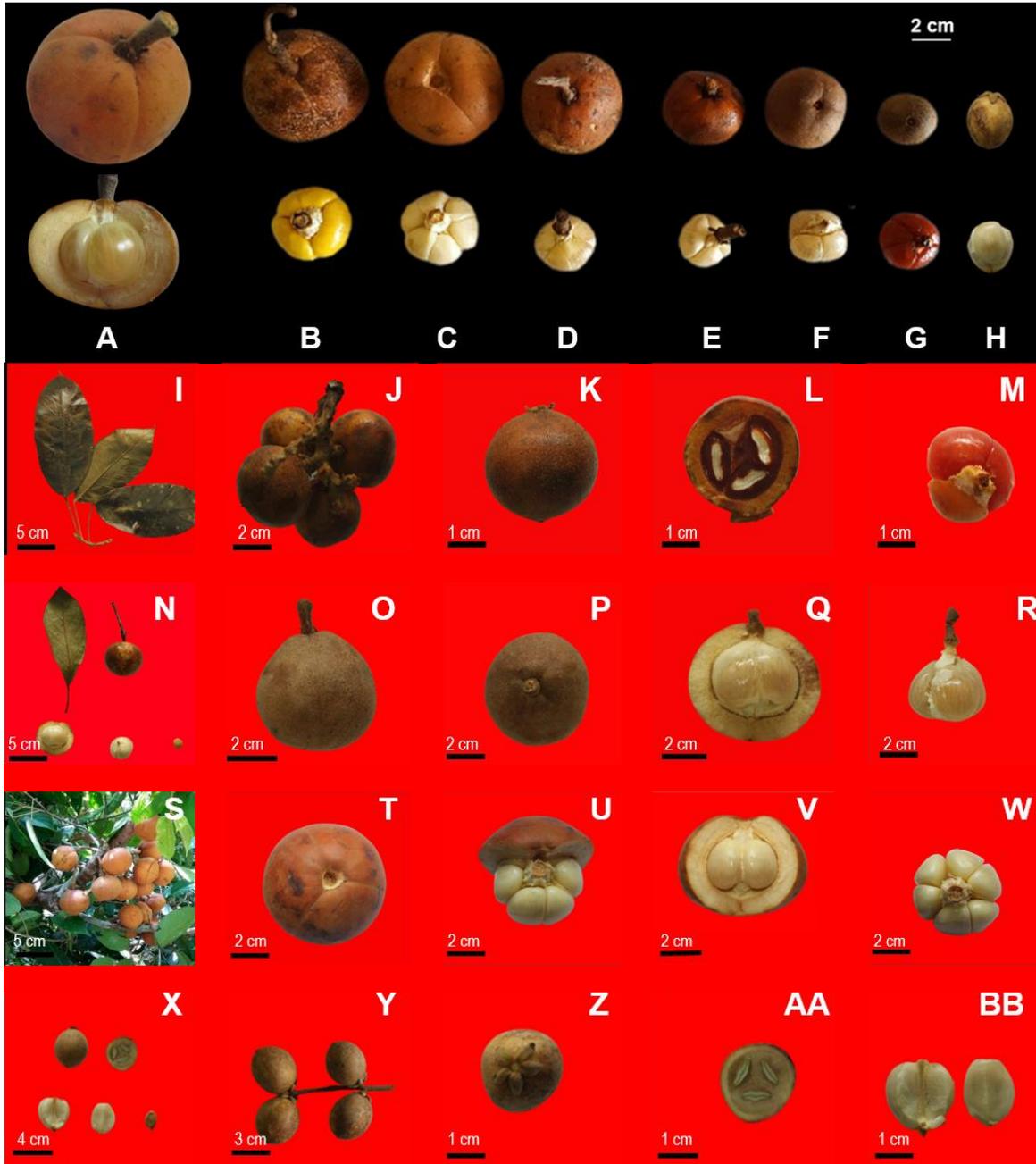
Examined specimens: BAME1, KAMPAR, Riau Province, Collector Maya and Nery; BAME2, BAME3,

BAME4, Bangkinang, Kampar, Riau Province, collector Nery.

Uses: arillode edible, sweet.

Note: This species is wellknown as Tampui Merah due to its dull red outer pericarp. The vernacular name “Tampui Merah” is sometimes misidentified with *B. deflexa*, which

has red aril. The fruits of *Baccaurea* sp2. are the smallest among other Tampui fruit in this province (please see the quantitative data presented in Figure 3). However, the brix level of aril of this species is the highest (28.00) among other examined species. Therefore, *Baccaurea* sp2. has the sweetest aril taste.



**Figure 2.** Morphology of *Baccaurea* from Riau Province, Indonesia. A and C. *B. macrocarpa* (A. Tampui Premium, C. Tampui), B. *B. edulis*, D. *Baccaurea* sp1, E. *Baccaurea* sp2., F. *Baccaurea* sp3., G. *B. deflexa*, H. *B. montleyana*, I-M. *B. deflexa* (I. leaves, J-K. fruits, L. Cross section of fruit showing 3-seeded part, N-R. *Baccaurea* sp3., (O. Fruit, P. Fruit base, Q. Vertical section of fruit showing white aril, R. aril), S-W. *B. macro carpa* (S. Habit, T. fruit base, U-V. Open pericarp showing milky white arillode, W. 6-seeded capsule), X-BB. *B. montleyana* (X. Fruit parts, Y. Fruit in lateral view, Z. Fruit base, AA. Cross section of fruit showing 3-seeded capsule, BB. Aril)

***Baccaurea* sp3**

Description: Tree. Leaves: petiole ca. 10 mm long, hairy; lamina papery, ecliptic to obovate, 9-11 x 3.8-13 cm, ratio of length and wide 2.2-2.4, acute at the base, margin entire, apex acuminate, upper surface glabrous; secondary veins ca. 7 pairs, alternate, ending closed at margin. Fruit almost (sub) globose, wider in the middle, 35-40 x 37-42 mm, apex almost flat; pericarp hairy outside, dull brown at maturity, ca. 6-8 mm thick; 3-seeded fleshy capsule, arillode translucent white to glossy white, placenta white; seed 8-9 x 7-8 mm, light brown, ecliptic shape, laterally flattened. Pedicle 3-4 mm long, thickened at abscission zone.

Vernacular name: Onggang (Riau)

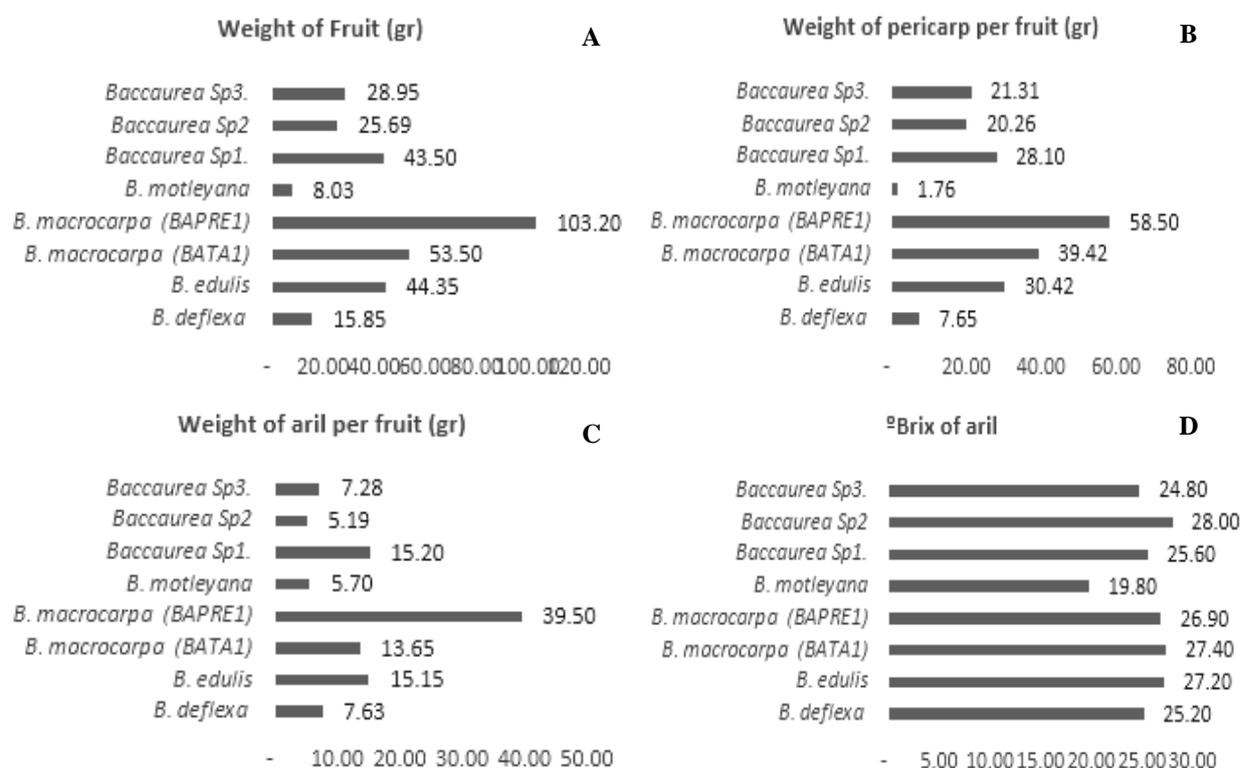
Examined specimens: BAONG1, BAONG2, Kuntu, Kampar, Riau Province, collector Rony.

Uses: arillode edible, sour to sweet.

Note: This species is locally known as Onggang. The main characteristic of fruit of *Baccaurea* sp3 is its densely hairy pericarp (Figure 1F and O) especially in immature fruit. The groove is not clearly seen at the fruit base and the fruit tip is flat fruit tip. These characteristics are different from other *Baccaurea* species in this study. The brix level of *Baccaurea* sp3 (24.80) is close to *B. deflexa* (Figure 3D).

In Riau, *Baccaurea* members are commonly found as wild species and considered as underutilized fruit trees. Most *Baccaurea* members have tree, treelet or shrub habit (Shu et al. 2008). The leaves are arranged in alternate

pattern and clustered apically. All *Baccaurea* species identified in this study have similar type of leaf, i.e. simple leaf blade, in which a petiole only bears one blade (laminae). However, the variations can be observed on leaf size, shape of leaf base and apex, as well as venation. *B. macrocarpa* (Tampui Premium) has the longest leaf length (up to 37 cm), followed by *B. motleyana* (up to 36 cm). The smallest leaf size is found in *Baccaurea* sp1. (Tampui Kecil) (ca. 11 cm in length). Generally, the ratio of leaf length and width ranges from 1.7-2.5. However, *B. macrocarpa* shows the highest ratio up to 3.5. This ratio is used to determine the leaf shape. In this study, we identified a total of three leaf shape, i.e. ecliptic, obovate and ovate. The venation of *Baccaurea* leaves are similar (scalariform). However, the tip of secondary vein is distinguished into two types, open or close at the ending. The secondary vein with ending open at the margin is a characteristic of *B. macrocarpa* and *B. motleyana*. The other species in this study have close ending of secondary veins, in which the ending of secondary vein is curved upward and connected to the upper one, as found in *B. deflexa*, *B. edulis*. *Baccaurea* sp1, *Baccaurea* sp2 and *Baccaurea* sp3. Morphological characters are the main character in plant identification and classification. The characteristic of these characters provides the key information on plant taxa as reported by many scientists (Dorji and Yapwattanaphun 2011; Kamiya et al. 2011; Harsono et al. 2011).



**Figure 3.** Quantitative data of *Baccaurea* fruits and their brix level of aril. A. Weight of fruit. B. Weight of pericarp per fruit. C. Weight of aril per fruit. D. Brix of aril

### Identification key

- 1 a. Fruit (sub) globose to globose ..... 2
- b. Fruit ellipsoidal ..... *B. montleyana*
- 2 a. Arillode translucent white, milky white, yellowish white ..... 3
- b. Arillode orangish red or yellow ..... 4
- 3 a. Fruit without groove or slightly short grooved near the base ..... 5
- b. Fruit with clear groove toward base ..... *B. macrocarpa*
- 4 a. Fruit 32-35 mm by 32-34 mm, not locucidally; pericarp densely hairy outside, reddish dark brown at maturity, ca. 3-4 mm thick; arillode glossy, orangish red, placenta whitish light brown ..... *B. deflexa*
- b. Fruit 45-62 mm by 43-61 mm, locucidally; pericarp glabrous outside, reddish brown at maturity, ca. 8-11 mm thick; arillode bright yellow, glossy and smooth, placenta white ..... *B. edulis*
- 5 a. Fruit with narrower apex; pericarp (Sub) glabrous to glabrous, dull red or dull brown; pedicle more than 5 mm ..... 6
- b. Fruit apex almost flat; pericarp hairy outside, dull brown at maturity; arillode translucent white to white; seed ecliptic shape; Pedicle 3-4 mm long..... *Baccaurea* sp3.
- 6 a. Fruit narrower toward apex; pericarp (sub) glabrous outside, dull red at maturity; fleshy white capsule; seed oblong..... *Baccaurea* sp2.
- b. Fruit slightly narrower toward apex; pericarp glabrous outside, brown at maturity; capsule translucent light brown; seed ecliptic ..... *Baccaurea* sp.1.

**Table 2.** Phytochemical screening of *Baccaurea* fruits from Riau

Species	Alkaloid			Terpenoid			Steroid			Flavonoid			Saponin			Tannin		
	P	A	S	P	A	S	P	A	S	P	A	S	P	A	S	P	A	S
<i>B. deflexa</i>	+	+	-	+	+	+	-	-	-	-	-	-	-	-	+	-	-	-
<i>B. edulis</i>	+	-	-	+	+	+	-	-	-	+	-	-	-	-	+	-	-	-
<i>B. macrocarpa</i>	+	+	-	+	+	+	-	-	-	+	-	-	+	-	+	-	-	-
<i>B. macrocarpa*</i>	+	+	+	+	+	+	-	-	-	+	-	-	-	-	-	-	-	-
<i>B. motleyana</i>	-	-	-	-	+	+	-	-	-	-	-	-	+	-	+	-	-	-
<i>Baccaurea</i> sp.1.	+	+	-	+	+	+	-	-	-	+	-	-	+	-	+	-	-	-
<i>Baccaurea</i> sp.2.	+	-	-	+	+	+	-	-	-	+	-	-	-	+	-	-	-	-
<i>Baccaurea</i> sp.3.	+	-	-	+	+	+	-	-	-	+	-	-	-	-	+	-	-	-

Note: \* BAPRE1, P: pericarp, A: aril, S: seed

### Phytochemical study

In this study, we investigated a total of six secondary metabolites (i.e. alkaloid, terpenoid, steroid, flavonoid, saponin and tannin) from three fruit parts (pericarp, aril and seed) of *Baccaurea*. A qualitative analysis was done to examine the presence of each secondary metabolite. For Alkaloid, the presence is indicated by precipitation at the bottom of mixture. While for steroid, terpenoid, flavonoid and tannin were indicated by the presence of coloration change. The presence of white soapy foaming substance at the top of mixture indicates the positive content of saponin. Table 2 shows that fruit parts of *Baccaurea* show the presence of alkaloid, terpenoid, flavonoid and saponin in most of the species. In contrast, steroid and tannin are absent in all fruit parts.

Alkaloid is organic compound that is typically alkaline (Matsuura and Fett-Neto 2015). It is found in about 20-30% of higher plants. This compound is nitrogen base compound (Gutiérrez-Grijalva et al. 2020), and contains at least one nitrogen atom (Sangi et al. 2008). The term of alkali is derived from Arabic origin (Gutiérrez-Grijalva et al. 2020), i.e. *al-qali*, meaning "from ashes". Alkaloid is pesticide properties in plant due to its toxicity (Ruby and

Sara. 2015) and has pivotal role in plant defense (against pathogens and herbivores) (Matsuura and Fett-Neto 2015). In this study, the presence of alkaloid is indicated by the red to orange precipitation at the bottom of the mixture. According to Kumar (2014), this coloration is due to potassium bismuth iodide reaction in Dragenroff reagent. The alkaloid test in this study shows that this compound is commonly found in pericarp (except in *B. motleyana*). While in aril, only three species of *Baccaurea* (*B. deflexa*, *B. macrocarpa* and *Baccaurea* sp.1.) show positive content. The presence of alkaloid in seed is only found in *B. macrocarpa* (Tampui Premium). Previous study on bark of *Baccaurea macrocarpa* also gave positif content of alkaloid (Erwin et al. 2018; Uddin et al. 2018). For *B. motleyana*, alkaloid test gave negative result for all fruit parts (pericarp, aril and seed). This result supports the study on *B. montleyana* by Sivadasan et al. (2020).

Terpenoid, also well known as isoprenoid (Block et al. 2019), is the widest natural product derived from terpene (Aharoni et al. 2015; Doncan et al. 2020). Terpenoid compounds have pivotal role in plant growth and development, as well as protection in the environment due to their specialized chemical interactions (Tholl 2015),

such as repelling herbivores or attracting pollinators (Bergman et al. 2019). Plant terpenoids are also reported in medicinal uses, as reported by (Malik and Ahmad 2017) on their antimicrobial and anticancer activity. In this study, the Lierman Bauchard reagen was used to test the presence of terpenoid, together with steroid (Malik and Ahmad 2017). This reagent contains anhydrate acetic acid and H<sub>2</sub>SO<sub>4</sub>, which will produce orange to purple coloration if a mixture has positive content of terpenoid, while steroid is indicated by green to blue coloration (Raman et al. 2018). The results of terpenoid test in this study show that all of the fruit parts from eight specimens indicate the presence of this compound, except in the pericarp of *B. motleyana*.

Steroids are low molecular weight compound, group of cholesterol (Sultan and Raza 2015). This compound functions in plant protection and increase the growth hormones (Patel and Savjani 2015). In this study, steroid is absent in all tested specimens. However, the presence of steroid in bark of *B. macrocarpa* had been reported by Erwin et al. (2019) and *B. courtallensis* (Sivadasan et al. 2020).

Flavonoid belongs to phenol group, a bioactive compound in plant (Panche et al. 2016) that functions to root and stem growth, support auxin hormone and also plays important role in pollination (Weston and Mathesius 2013). The reduction of HLC and magnesium in the mixture will form magenta, orange to dark red or yellow coloration that indicates the positive content of flavonoid (Robinson 1995). In this study, flavonoid is absent in aril and seed of eight examined specimens. The pericarps of two *Baccaurea* species, *B. deflexa* and *B. motleyana*, also give the negative result in flavonoid test.

The saponin test result is indicated by the white soapy foaming substance on the top of mixture. This substance is caused by the soapy active compound from colloidal solution that formed after being strongly shaken (Faizal and Gellen 2013). In contrast with the result of alkaloid, terpenoid and flavonoid tests that are commonly present in pericarp, the saponin test indicated that this compound is more common in seed of *Baccaurea* in this study (Table 2). This compound is absent in pericarps and arils of examined *Baccaurea*.

Tannin is a group of gallic acid content that produce astringent (Pizzi 2019) and bitter taste (Ashok and Uphadyaya 2012). The name of this compound comes from the compound in tanning process, that used in coloring leather, (Pizzi 2019), textile and other products (Kyund 2018). Its general appearance varies from white, colorless, glossy or red (Okuda and Ito 2011). The presence of tannin in the mixture is indicated by the presence of green or blue color. However, there were no tested specimens of *Baccaurea* showed positive content of tannin.

The result of this study provides the first morphological record as well as phytochemical data of *Baccaurea* from Riau. Morphologically, *Baccaurea* species can be distinguished based on leaf characteristic (venation, size and shape), floral pattern and fruit characters. Further study is pivotal for determining unsolved taxonomical status of three *Baccaurea* species (*Baccaurea* sp.1, *Baccaurea* sp.2 and *Baccaurea* sp.3). The phytochemical results show that

terpenoid is more abundant in *Baccaurea* fruit in this study than other fruit parts (aril and seed).

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