

Diversity wild banana species (*Musa* spp.) in Sulawesi, Indonesia

HASTUTI^{1,2,♥}, PURNOMO³, I. SUMARDI⁴, BUDI S. DARYONO^{5,♥♥}

¹Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sleman 55281, Yogyakarta, Indonesia. Tel.: +62-274-580839; Fax.: + 62-274- 6492354, ♥email: tutibio_03@yahoo.com

²STKIP Pembangunan Indonesia Makassar. Jl. Inspeksi Kanal No 10, Gowa, South Sulawesi, Indonesia

³Laboratory of Plant Systematics, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sleman 55281, Yogyakarta, Indonesia

⁴Laboratory of Plant Structure and Development, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sleman 55281, Yogyakarta, Indonesia

⁵Laboratory of Genetics and Breeding, Faculty of Biology, Universitas Gadjah Mada. Jl. Teknika Selatan, Sleman 55281, Yogyakarta, Indonesia.

Tel.: +62-274-580839; Fax.: + 62-274- 6492354, ♥♥email: bs_daryono@mail.ugm.ac.id

Manuscript received: 12 November 2018. Revision accepted: 25 February 2019.

Abstract. Hastuti, Purnomo, Sumardi I, Daryono BS. 2019. Diversity wild banana species (*Musa* spp.) in Sulawesi, Indonesia. *Biodiversitas* 20: 824-832. Indonesia is known as one of the centers of banana diversity in the world. There are 70 species of wild banana in the genus *Musa*, 12 of them it was found in Indonesia. Sulawesi was located in the Wallace Line, which is a meeting between the Sunda and Sahul exposures, and has many endemic species, some of which are wild banana species. However, studies on wild banana in Sulawesi are still limited. This study focuses on species of wild bananas found in Sulawesi. Purposive sampling was used to select banana example from wild, cultivated area, residential areas and research garden. Observation was carried out in the field as well as using a collection herbarium and living specimens. The observation was done by observing the characteristics of the sample according to the guidance on Descriptor for Banana. Identification was done by matching the sample with herbarium and relevant references. The results showed that there were four species of wild bananas found on the island of Sulawesi. These are *Musa balbisiana* Colla, *Musa acuminata* Colla var. *zebrina* (v.Houtte) Nasution, *Musa acuminata* Colla var. *banksii* (F.Muell.) N.W Simmonds, *Musa acuminata* Colla var. *lutraensis*, *Musa acuminata* Colla var. *sigiensis*, *Musa acuminata* Colla ssp. *microcarpa* Becc., *Musa borneensis* Becc. and *Musa textilis* Nee. Four wild banana accessions had never been reported before. These were *Musa acuminata* var. *zebrina*, *Musa acuminata* var. *lutraensis*, *Musa acuminata* var. *siginensis* and *Musa borneensis*.

Keywords: Diversity, wild banana, identification, *Musa*, Sulawesi Island

INTRODUCTION

The term "banana" generally includes a number of species and hybrids, which are in the genus *Musa* in the Musaceae Family. This family includes only two genera, *Ensete* and *Musa*. *Musa* was divided into four sections based on basic chromosome, which are *Australimusa* and *Callimusa* with n=10 and *Eumusa* and *Rhodochlamys* with n=11 (Cheesman 1947). Recently Hakkinen restructured *Musa* species into two sections, *Musa* and *Callimusa*, based on the DNA analyses (Hakkinen 2013). Most of the cultivated bananas available today come from two wild bananas ancestors which are *M. acuminata* and *M. balbisiana*. These species generally seedy, not-pulpy and are inedible (Mukunthakumar et al. 2013). However, other plant parts have been used from *M. balbisiana* such as pseudostems, leaves, and inflorescence (Borborah et al. 2016). Vegetative cultivation process can cause genetic erosion, due to the limited source of genetic ancestors. Genetic erosion produces plants vulnerable to disease, pests and ecological changes (Miller et al. 2010; Perrier et al. 2011). Wild banana species could be of pathogen genes that can be used to develop resistant commercial varieties (Argent 1976; Nasution and Yamada 2001; Mukunthakumar et al., 2013). Therefore, collection, conservation, and characterization of wild banana germplasm are needed to improve the genetic improvement

of bananas (Nasution and Yamada 2001; Kulkarni et al. 2012).

Indonesia is known as one of the centers of *Musa* banana diversity (Daniells et al., 2001). There were 70 species of banana in the genus (Hakkinen 2013), 12 are found in Indonesia (Nasution and Yamada 2001). Wild banana species can be found on all major islands in Indonesia, including Sumatra, Java, the Lesser Sunda Islands, Kalimantan, Sulawesi, Maluku and Papua (Sulistiyarningsih et al. 2014). Nasution and Yamada (2001) reported three species of wild bananas on Sulawesi Island: *M. acuminata*, *M. celebica*, and *M. textilis*. In a previous study, Sulistiyarningsih et al. (2014) collected specimen from Lore Lindu National Park, Palu (Central Sulawesi); Manado, Tomohon (North Sulawesi); Soppeng (South Sulawesi); and Mt. Watuwila, Kolaka (Southeast Sulawesi) they reported two new record wild banana species in Sulawesi, which were *M. balbisiana* and *M. itinerans*.

Wild banana exploration on the island of Sulawesi is still considering its location in the transition zone and along the Wallace Line, which is a meeting between the Sunda and Sahul Exposures. In addition, Sulawesi Island is also one of center of biodiversity in Indonesia (Wallace 1869). Wallace noted that there are many species of endemic flora and fauna found on the island. Geographically and geologically, the island of Sulawesi has a more complex history. The magnitude of complexity of the existing

landscape on the island of Sulawesi is associated with the high diversity and endemic properties it possesses (Cannon 2005; Nugraha and Hall 2018). However, compared to Kalimantan Island records of plant collected in Sulawesi are still relatively limited.

Research on the taxonomy of bananas has long been developing since the nineteenth century, however, even now some species still had unclear taxonomic status. One factor is limited number of wild species found (MusaNet 2016). For this reason, it is necessary to study the diversity of wild banana on the Sulawesi Island to complete the data on the distribution and wild banana species, which might be useful as sources of gene variation in breeding programs and for improving the genetic characters of bananas in the future.

MATERIALS AND METHODS

Study area

Sampling was performed in several districts in the provinces on Sulawesi Island. Information about the existence of wild bananas was obtained from local people. Sampling location can be seen in Figure 1.

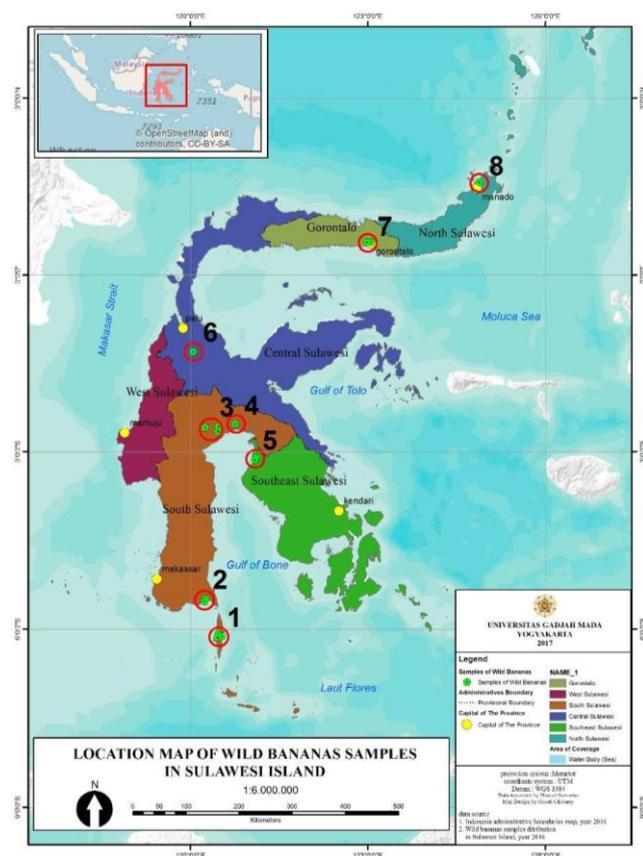


Figure 1. Location map of wild banana samples on the island of Sulawesi, Indonesia

Table 1. Wild *Musa* species and their site of collection

Sample Collection	Location	Latitude	Longitude
SLY-1	Selayar islands	S 06 06.651	E 120 28.239'
SLY-2	Selayar islands	S 06 07.420'	E 120 27.427'
SLY-3	Selayar islands	S 06 07.052'	E 120 31.583'
BLK-1	Bulukumba	S 05 32.092'	E 120 14.537'
BLK-2	Bulukumba	S 05 32.111'	E 120 14.539'
LU-1	North Luwu	S02 35. 195'	E 120 14.714'
LU-2	North Luwu	S 02 39.695'	E 120 28.257'
LU-3	North Luwu	S02 34. 508'	E 120 28.565'
LT-1	East Luwu	S 02 31. 827'	E 120 45.559'
LT-2	East Luwu	S 02 31. 827'	E 120 45.559'
KU-1	North Kolaka	S 03 06.082'	E 121 06.190'
KU-2	North Kolaka	S 03 07.070'	E 121 05.896'
PAL	Sigi	S 01 18.370'	E 119 5. 155'
MND	North Minahasa	N 01 34.503'	E 124 53.129'
GO-1	Gorontalo	N 00 33.927 '	E 123 02.915'
GO-2	Gorontalo	N 00 33.663'	E 123 01.451'

Sample collection

The study was conducted from March to May 2016. Samples were chosen using a purposive sampling method. Surveys and samples included the Selayar Islands (Kepulauan Selayar), Bulukumba, North Luwu, East Luwu District (South Sulawesi), North Minahasa District (North Sulawesi), Sigi District (Central Sulawesi), North Kolaka District (Southeast Sulawesi) and Gorontalo (Gorontalo). Samples were obtained from the wild, cultivated area, residential areas, and research garden. Plants were observed directly in the field and photographed with a digital camera. Sucker was collected to planted and observed for characters that were not clear in the field at the time of collection. Currently, these banana are growing in private gardens located in Bulukumba District, South Sulawesi. Data taken at the sampling site include geographic data, local names, local use and morphological characteristics including pseudostems, leaves, bunches, male and fruit flowers. Identification was done the aforementioned vegetative and generative organ characteristics of *Musa* spp. based on characters descriptions according to "Descriptor for Banana" issued by IPGRI (1996). Herbarium specimen from Bogoriense Herbarium (BO) were also compared to sample and *Musa* spp. description.

Data analysis

Species identification was done by cross-checking sample with images in the "Musalog" catalog of germplasm (Daniells et al. 2001), Pisang-Pisang liar di Indonesia (Nasution and Yamada 2001), Katalog Pisang (Poerba et al. 2016), Deskripsi Pisang (Poerba et al. 2018), herbarium collection from BO, herbarium collections of the Kew Garden (<https://www.kew.org/>) and those reference that are cited where relevant to particular species.

RESULTS AND DISCUSSION

Sulawesi Island is the eleventh largest island in the world and the fourth largest island in Asia after New Guinea, Borneo, and Sumatra. Sulawesi Island has high

biodiversity and complex geological history and has attracted the attention of geologist since the nineteenth century. The complex history is mirrored in the geology of Sulawesi, which is a composite island at the center of a collision zone. Sulawesi is located along the transition zone commonly called the Wallace Line. Many species of animals endemic in the region. Therefore, the island of Sulawesi is important for study because of its diversity of animals and plants, the distributions of animal and plant are strongly influenced by past geological history (Nugraha and Hall 2018)

The results of this study showed that there were four species of wild banana found on the island of Sulawesi: *M. balbisiana*, *M. acuminata* var. *zebrina*, *M. acuminata* var. *banksii*, *M. acuminata* var. *lutraensis*, *M. acuminata* var. *sigiensis*, *M. acuminata* ssp. *microcarpa*, *M. borneensis* and *M. textilis*. There were four accessions of wild banana that never have recorded before: *M. acuminata* var. *zebrina*, *M. acuminata* var. *lutraensis*, *M. acuminata* var. *sigiensis*, and *M. borneensis*. Hakkinen (2007) state many areas in the center of the range of wild bananas in Southeast Asia that have not been systematically explored and the discovery of new species likely continues. Wild banana species were found to grow at an altitude of 10-1513 m above sea level (asl), in gardens, swamps to the edge of forest. According to Argent (1976) the genus *Musa* mainly grow spread out along the margins of tropical rainforests and streams. Wild banana is pioneer plants and can grow in open habitats and they grow limited as separate small populations. For this reason, they can develop very large genetic variations (Hakkinen and Meekiong 2004). The most common species is *M. acuminata*, which was found in almost every province except Gorontalo. Specific characters each wild banana species and description of each species can be seen below.

Identification key species wild *Musa* on the island of Sulawesi, Indonesia

1. a. Flower and fruit in one series *Musa borneensis* Becc.
b. Flower and Fruit at two series 2
2. a. Bract not revolute before falling 3
b. Bract revolute before falling *Musa acuminata* Colla
3. a. Bract color surface red, imbricate with green tinted at tip and shiny *Musa textilis* Nee
b. Bract color surface purple, imbricate with yellow tinted at tip and waxy *Musa balbisiana* Colla

Identification key intraspecies *Musa acuminata* Colla

1. a. Bract imbricate when young *M. acuminata* var. *zebrina*
b. Bract not imbricate 2
2. a. Bract color green and surface waxy
..... *M. acuminata* var. *banksii*
b. Bract color purple and waxy 3
3. a. Peduncle very hairy/short hairs (similar to velvet)
..... *M. acuminata* var. *lutraensis*
b. Peduncle slightly hairy 4

4. a. Fruit shape curved-slight and pedicle hairless
..... *M. acuminata* ssp. *microcarpa*
b. Fruit curve and pedicle hairy
..... *M. acuminata* var. *sigiensis*

Morphological description

Musa balbisiana Colla

Synonymous name: *M. balbisiana* Colla, Mem. Gen. Musa. 56 (1820). M. XI Pissang batu seu pissang bidjii Rumph. Herb. Amb. 5, 132, t. 60 Figure f. (1750). *M. troglodytarum* L. Sp. Pl. ed. II. 1478 p.p. (1763). *M. seminifera* Lour. Fl. Cochinch. 644 p.p. (1790). *M. sapientum* L. ("the wild sort") sensu Roxb. Hort. Beng. 19 (1814); Corom. Pl. t. 275 (1819); Fl. Ind. 2, 484 (1824) et ed. 2. 663 (1832); non L. *M. paradisiaca* L. sec. Trimen, Flora of Ceylon 4, 265 (1898); non L. *M. sapientum* ssp. *seminifera* form. *pruinosa* King MSS ex Baker, Ann. Bot. 7, 214 (1893); Cheesman, Kew Bull. 1948, 327. *M. sapientum* var. *pruinosa* King MSS ex Cowan and Cowan, Trees of North Bengal, 135 (1929). *M. balbisiana* Colla, Cheesman, Kew Bull. 1948, 327. Type: India orientalis, ex H. Rip 1820 *Anonymous* (lecto designed by Hakkinen and Vare: TO, n.v) (2008).

Local name: *utti batu* (Bugis), *loka batu* (Selayar), *pisang batu*, *abati* (Gorontalo).

Description: *Pseudostem* aspect medium to robust, height 3-5,15 m, color medium green to green (Figure 2.A) with pink-purple, brown to black or absent blotch color. *Sap* color milky to red-purple. Number of *sucker* 1-7 and are close to parent. *Petiole* green with brown to black blotch color, length 20-48 cm. *Petiole* canal leaf wide, erect and curved inward (Figure 2.B). *Leaf* habit intermediate to erect, length 125-193 cm, width 47-77 cm, upper surface dark green and shiny, lower surface light green and dull, midrib dorsally and ventrally green, leaf base rounded on both sides, apex truncate (Figure 2.C). *Male bud* ovoid, normal and waxy (Figure 2.D). Bract with small shoulder and an intermediate apex, *color* externally red-purple and internally pink-purple of bract, tinted with yellow and not revolute. *Male flower* biseriate, compound tepals white, free tepal translucent white and apex greatly developed, 5 stamens, filaments white, straight style, stigma cream colored, ovary cream colored and straight, dominant male flower cream. *Peduncle* green and hairless, bunch position hanging at angle 45 and rachis position at angle. *Fruit* in bunch compact to lax, persistent, length 6-13 cm; 6-16 pieces per hand in two rows, straight and apex blunt-tipped without any floral relict (Figure 2.E). *Peel* green on immature fruit, yellow on mature fruit. *Seed* globular, brown and wrinkled (Figure 2.F).

Distribution: Found on Selayar Island (Kepulauan Selayar), Bulukumba, North Luwu District (South Sulawesi) and Gorontalo.

Geographical Distributions: Distributed in the Philippines, Thailand, and Indonesia (Daniells et al. 2001).

Habitat: Grows in backyard as well as wild in open areas, and flatlands that get enough sunlight.

Altitude: Grows at elevations 10-249 m above sea level.

Utilization: Based on personal communication with local people young fruit are used as a medicine for gastritis;

suckers are used for ear medicine; pseudostems are used instead of rope; plants are cultivated to use the stems as animal feed; young fruit and male bud are used in vegetable blends.

Noted: *M. balbisiana* has a local name of banana stone (*utti batu, pisang abati, loka batu*), this name is based on the number of seeds found in the fruit. *M. balbisiana* from Sulawesi Island has special characters such as medium to large size pseudostem, that are green to dark green with reddish, brown to black blotch, sap purple-red to milky. The bract are pink-purple and tips overlap, colors are not uniform because there is a yellow color on the tip, and the bract not rotate before falling. The characters found were the same as those reported by Sulistyaningsih et al. (2014) and Sunandar (2017).

***Musa acuminata* Colla var. *zebrina* (v.Houtte) Nasution**

Synonymous name: in Van Houtte, Flore des Serres 10: 223 (1854) — Type: Planchon (1854), Flore des Serres 10: 223, t. 1061 (lecto-, here designated). *Musa acuminata* var. *zebrina* (Van Houtte ex Planch.) Nasution, Journal Biologi Indonesia 1: 282 (1993).

Local name: forest banana (*loka utang*)

Description: *Pseudostem* aspect slender to medium, height 2.83-4.60 m, color green-yellow with brown blotch and shiny (Figure 3.A). *Sap* color watery. Number of *sucker* 2 and close to parents. *Petiole* 25-47 cm long, green with brown blotches and petiole canal leaf open with margins spreading (Figure 3.B). *Leaf* habit intermediate, length 87-237 cm, width 58-59 cm, upper surface green and shiny, lower surface green-yellow and dull, midrib dorsally yellow and ventrally green, leaf base pointed on both sides, apex truncate (Figure 3.C). *Male bud* shape like a top, normal and waxy (Figure 3.D). Bract have bases with large shoulders and intermediate apex, *color* externally red-purple and internally orange-red; imbricated when young and revolute before falling. *Male flower* biseriate, compound tepal white, free tepal transparent white, and apex very developed, 5 stamen, white filaments, stigma yellow and ovary arched, style curved under stigma and dominant male flower pink-purple (Figure 3.E). *Peduncle* dark green and slightly hairy. *Bunch position* horizontal, *rachis position* at angle. *Fruit* in bunch compact, deciduous, length 11-14 cm with 13-18 pieces per hand in two rows, shape slightly curved and blunt apex without any floral relict. *Pedicle* length 1.5-2 cm and hairless. Peel on immature fruit green, yellow with brownish spots on mature. Seed angular, brown, wrinkled (Figure 3.F).

Distribution: Found in Selayar Island (Kepulauan Selayar District).

Geographic distributions: Grow on open area in Java at 250-900 meter from sea level (Nasution and Yamada 2001).

Habitat: Grow wild in altitude areas with high humidity levels.

Altitude: 1513 m above sea level.

Utilization: unknown.

Noted: This subspecies also commonly called blood banana, because when young the leaf is red like blood.

Male bud imbricate when young and male flower is dominant pink color. This characters not common was found in *M. acuminata* species.

Musa acuminata* Colla var. *lutraensis

Synonymous name: -

Local name: Forest banana/monkey banana (*pisang unye*).

Description: *Pseudostem* aspect slender, height 5.83 m, color green-red and shiny with red-purple blotches (Figure 4.A). *Sap* color watery. Number of *sucker* 2 and close to parents. *Petiole* 42 cm long, petiole canal leaf open with erect margins (Figure 4.B). *Leaf* habit erect, length 320 cm, width 85 cm, upper surface dark green and shiny, lower yellow-green and dull, midrib dorsally and ventrally green color, leaf base pointed at both side, apex truncate. *Male bud* shape like a top, normal and waxy (Figure 4.D). *Bract* with large shoulders and slightly pointed, color red-purple externally and yellow-purple internally, not tinted and revolute before falling. *Male flower* biseriate, compound tepals cream colored free tepal transparent white; 5 stamens, filament white, stigma cream, style shape curved under the stigma, ovary arched, dominant male flower cream. *Peduncle* green and very hairy with short hair (Figure 4.C). *Bunch position* hanging vertically, *rachis position* falling vertically. *Fruits* in bunch compact, deciduous, 6 cm long, 21-22 pieces per hand in two rows, shape slightly curved with bottlenecked apex without any floral relict. *Pedicle* 1.5-2 cm long and hairless. *Peel* green on immature fruits; yellow on mature fruits (Figure 4.E). *Seed* brown, angular and wrinkled (Figure 4.F).

Distribution: Found in the North Luwu District, South Sulawesi.

Habitus: Grows wild in the region close to the rivers.

Altitude: 270 m above sea level

Utilization: unknown

Noted: This species is different from other species in the pseudostem color green-red and the peduncle very hairy with short hair (similar velvet touch).

***Musa acuminata* Colla var. *banksii* (F.Muell.) N.W Simmonds**

Synonymous name: Fragmenta Phytographiae Australiae 4: 132 (1864). — Type: Australia, Queensland, Mt. Elliot, Elliot Fitzalan, (lecto-, MEL 621531!, designated by Simmonds [1957: 464] “type”; iso-, BRI). *Musa acuminata* Colla subsp. *banksii* (F.Muell.) N.W.Simmonds (1957: 463).

Local name: forest banana.

Description: *Pseudostem* aspect slender to medium, height 3.54-3.71 m, color green with pink blotches and shiny (Figure 5.A). *Sap* color watery. Number of *sucker* 1-6 in number and close to parent. *Petiole* 26-62 cm long with brown blotch; petiole canal leaf wide with erect margin (Figure 5.C). *Leaf* habit erect, length 1.9-2.69 m, width 64-74 cm, upper surface green and shiny, lower surface yellowish-green and dull. Midrib dorsally and ventrally green. Leaf base pointed at both sides, apex truncate (Figure 5.B). *Male bud* shape intermediate, normal, and waxy (Figure 5.D). *Bract* small shoulders and

apex slightly pointed, color green externally and white-yellowish internally; revolute before falling. *Male flower* biseriate, compound tepals white, free tepals transparent white, 5 stamens, filaments white, stigma brown, style white, straight ovary, dominant male flower cream (Figure 5.E). *Peduncle* green and slightly hairy, *bunch* position horizontal, *rachis* position falling vertically. *Fruits* in bunch lax, deciduous, length 6-9 cm, 15-16 pieces per hand in two rows, shape curved with bottlenecked apex without any floral relict. *Pedicle* 1 cm long and hairless. *Peel* green on immature fruits and yellow on mature fruit. *Seed*. Seed brown, angular and wrinkled (Figure 5.F).

Distribution: Found on East Luwu District, South Sulawesi.

Geographic distributions: New Guinea, Australia (Queensland), Samoa (Daniells et al. 2001).

Habitat: Grows edge of backyard.

Altitude: 117 m above sea level.

Utilization: unknown.

Noted: This species is different from other species, the bract color is green and male bud intermediate shape. In general *M. acuminata* species have purple bract color and like a top shape.

Musa acuminata* Colla var. *sigiensis

Synonymous name:-

Local name: monkey banana (*loka ibo*).

Description: *Pseudostem* aspect slender, height 4.60-5.50 m, reddish-whiten with red blotch and shiny (Figure 6.A). *Sap* color watery. Number of *sucker* 2 and close to parents. *Petiole* 56-75 cm long, red-brown color, petiole canal leaf straight with erect margins (Figure 6.B). *Leaf* habit erect, length 227-390 cm, width 49-69 cm, upper surface dark green and shiny, lower surface green and dull, midrib dorsally and ventrally light green. Leaf base pointed on both sides, apex truncate (Figure 6.C). *Male bud* shape like a top, normal and waxy. *Bract* base large shoulders and slightly pointed apex, color red-purple externally and red-yellow internally (Figure 6.E), revolute before falling. *Male flower* biseriate, compound tepals white, free tepal transparent white and apex very developed, 5 stamens, filament white, stigma cream, ovary arched, style curved under stigma, dominant male flower cream. *Peduncle* dark green and slightly hairy (Figure 6.D). *Bunch* position horizontal, *rachis* position falling vertically. *Fruits* in bunch lax, deciduous, 6-9 cm long with 10-16 pieces per hand in two rows, shape slightly curved and bottleneck apex without any floral relict. *Pedicle* 1 cm long and hairy. *Peel* on immature fruit green, yellow on mature fruit (Figure 6.F). *Seed* brown, angular and wrinkled.

Distribution: Found in the Sigi District, Central Sulawesi.

Habitat: Grow wild in upland areas.

Altitude: 828 m above sea level.

Utilization: unknown.

Noted: This species is different from other species in the pseudostem color is reddish-whiten with red blotch and the pedicle is hairy.

***Musa acuminata* Colla ssp. *microcarpa* Becc.**

Synonymous name: Nelle Foreste di Borneo 612 (1902). — Type: [Malaysia], Borneo, Ragiato di Sarawak, 186[6], [O. Beccari] no. 3351 (lecto-, FI!, here designated). ISONYM. — *Musa microcarpa* Becc., Webbia 5: 548. (Martelli 1923) “sp. n.”. *Musa acuminata* Colla subsp. *microcarpa* (Becc.) N.W.Simmonds, Kew Bulletin 11: 467 (1957, “1956”); *Musa acuminata* var. *microcarpa* (Becc.) Nasution, Memoirs of the Tokyo University of Agriculture 32: 86 (1991).

Local name: Monkey banana (*punti lanceng*).

Description: *Pseudostem* aspect slender, height 2.75-3.99 m, color green with red-purple blotch and shiny (Figure 7.A). *Sap* color watery. Number of *sucker* 2-5 and close to parent. *Petiole* length 56-75 cm, petiole canal leaf open with margin spreading (Figure 7.B). *Leaf* habit erect, length 220-260 cm, width 59-75 cm, upper surface green and shiny, lower surface green and dull, midrib yellow dorsally and green ventrally, leaf base pointed on both sides, apex truncate (Figure 7.C). *Male bud* intermediate, normal and waxy (Figure 7.E). *Bract* base shape with large shoulder and pointed apex, color red-purple externally and red-yellow internally and revolute before falling. *Male flower* biseriate, compound tepals white, free tepal transparent white and apex very developed, 5 stamens, filament white, stigma cream, style white, style curved under the stigma, ovary arched and dominant male flower cream. *Peduncle* green and slightly hairy (Figure 7.D). *Bunch* position hanging vertically, *rachis* position falling vertically. *Fruits* in bunch lax to compact, deciduous, 5.5-12 cm long with 16-26 pieces per hand in two rows, stright curved shape with bottleneck apex without any floral relict. *Pedicle* 0.5-1 cm long and hairless. *Peel* on immature fruit green, yellow on mature fruit. *Seed* black, angular, wrinkled (Figure 7.F).

Distribution: North Kolaka District, Southeast Sulawesi.

Geographic distributions: Indonesia, Malaysia, Thailand, grow wild in South Borneo at lowland 100 meters from sea level (Daniells et al. (2001); Nasution and Yamada (2001).

Habitat: Grow wild on the edge of the forest.

Altitude: 114-133 m above sea level.

Utilization: unknown.

Noted: This species is different from other species in the pseudostem color is green with red-purple blotch until purple without blotch. Color of bract externally purple and intermediate shape male bud. Bract base shapes large shoulder and pointed apex.

The most common species *Musa* found in this study were *M. acuminata* species, conducted *M. acuminata* var. *zebrina*, *M. acuminata* var. *banksii*, *M. acuminata* ssp. *Microcarpa*, *M. acuminata* var. *lutraensis* and *M. acuminata* var. *sigiensis*. *M. acuminata* var. *zebrina*, *M. acuminata* var. *lutraensis* and *M. acuminata* var. *sigiensis* was subspecies/varieties of *M. acuminata* was first reported on the island of Sulawesi. According to Javed et al. (2002), the high variation under *M. acuminata* is due to geographic isolation, alteration of gene abundances in small populations because of genetic drift and hybridization between different subspecies. Mutations could also be

important factors that contribute to *M. acuminata* diversity. Inconsistencies among subspecies indicate the appearance of hybrid and subsequent introgression or different lines with large morphological variation (Janssens et al. 2016). Ude et al. (2002) stated that chromosome rearrangement and cross-hybridization were responsible for the extent of genetic variation in *M. acuminata*.

The *M. acuminata* species were found in quite different habitats of 113-1513 m asl, and growing mostly on the edge of the forest up the slopes with high humidity and shade. The same observation was reported by Samarasinghe & Jayaweera (2008), who studied the morphological and molecular diversity of *M. acuminata* and *M. balbisiana* in Sri Lanka. *M. acuminata* grew generally at 170-1500 m asl on humid mountain slopes and forest edges. *M. acuminata* has a local name *pisang hutan* (forest banana), *pisang monyet*, *loka ibo* and *punti lanceng* (monkey banana), the same names for different species gives difficulties in the introduction of the species. This may, in turn, lead to a more serious issue in determining conservation due to uncertainty about true biological diversity (Susandarini et al. 2013). The morphological characters of *M. acuminata* from Sulawesi Island included pseudostems that were generally slender, erect-intermediate leaf habit, watery sap color, leaf shape pointed at both sides, bract color uniform, presence of hair on fruit bunches and bract that rotate before falling.

Hapsari (2014) reported special characters for species of *M. acuminata* at Purwodadi Botanic Garden; slim pseudostem, leaf habit erect, male bud shape pointed to ovate, male bud apex pointed, color of bract externally purple, orange-red, yellow and yellow-green, pedicle short, seeds black and irregular. *M. acuminata* contributes to the cultivation of banana domestication which is a hybridization between *M. acuminata* subspecies in Southeast Asia and Western Melanesia. Heterozygosity structure in hybrid results the crosses due to the chromosome rearrangement between subspecies of the *M. acuminata* ancestor, which contribute to sterility. This sterility is related to the formation of more fruit flesh, parthenocarpic properties and suitability for consumption (Perrier et al. 2011).

***Musa borneensis* (Becc.)**

Synonymous name:-

Local name: monkey banana (*pisang unye*).

Description. *Pseudostem* aspect slender, height 4.05-4.70 m, color light green and shiny (Figure 8.A). *Sap* color watery. Number of *sucker* 1-2 and close to parent. *Petiole* length 70-96 cm; color yellow-green, petiole canal leaf straight with erect margin (Figure 8.B). *Leaf* habit erect, length 278-370 m, width 64-78 cm, upper surface yellow-green and shiny, lower surface light green and dull, midrib green dorsally and yellow-green ventrally, leaf base pointed on both sides, apex truncate (Figure 8.C). *Male bud* rounded, normal, tinted with yellow color, and not waxy (Figure 8.D). Bract base with large shoulders, intermediate apex, red-orange externally, pale orange internally and not revolute before falling. *Male flower* uniseriate, compound tepals white, free tepal opaque and apex very developed

(Figure 8.E), 5 stamens, filament white, stigma white, white style and straight, dominant male flower cream. *Peduncle* green with purple-brown spots and hairless. *Bunch position* at an angle, *rachis position* falling vertically. Fruits in bunch lax, persistent, length 8-9 cm, 5-7 pieces in one row, straight and blunt apex without any floral relict. *Pedicle* hairless, length 1-1.5 cm. *Seed* brown, oval and wrinkled.

Geographic distribution: spread in lowland and swampy regions of Vietnam, Peninsular Malaysia, Borneo and Sumatra (Nasution and Yamada 2001; De Langhe et al. 2009).

Distribution: North and Eastern Luwu District, South Sulawesi.

Habitat: Grows wild in swamp areas and edge of the garden

Altitude: 117-321 m above sea level.

Utilization: Unknown.

Noted: This species different from other species in the male bud shape is rounded, tinted with yellow color and not waxy. Bract external color is red-orange and internal pale orange. Free tepal opaque; fruits 8-9 cm long; 5-7 pieces in one row. *M. borneensis* is a species from the *Callimusa* section which was reported for the first time at South Sulawesi. So far, *Callimusa's* has only been reported occur around Sumatra, Kalimantan, Java and Malaysia (Janssens et al. 2016). This species has been found in eastern and northern Luwu (South Sulawesi) growing in shaded and marshy areas. Sulistiyarningsih (2017) previously discovered *M. borneensis* var. *donggalaensis* growing wild on the coast southwest of Donggala, Central Sulawesi. Some characters that distinguish with *M. borneensis* var. *donggalaensis* are sap color watery, petiole canal straight with erect margins, fruit bunches hairless, bract color red-orange, bract not revolute before falling and free tepals opaque white in color.

***Musa textilis* Nee**

Synonymous name: -

Local name: *pisang abaka*, pisang manila, pisang serat

Description: *Pseudostem* aspect slender, height 1.58-1.90 m, color green with pink-purple blotch and shiny (Figure 9.A). *Sap* color milky (Figure 9.B). Number of *sucker* 1-4 and close to parent. *Petiole* length 28-30 cm and petiole canal leaf curved inward (Figure 9.C). *Leaf* habit intermediate-erect, length 98-120 m, width 25-37 cm, upper surface dark green and shiny, lower surface green and dull, midrib dorsally green and yellow-green ventrally, leaf base rounded on both sides, apex truncate (Figure 9.D). *Male bud* intermediate with tinted green, normal and shiny (Figure 9.E). Bract base with small shoulders and very pointed apex, color red externally and internally, not revolute before falling. *Male flower* biseriate, compound tepals white, free tepal transparent white, apex very developed apex, 5 stamens, filament white, style white and straight, stigma cream, ovary arched, dominant male flower cream. *Peduncle* green and hairless, *rachis position* at an angle. *Fruits* and *seeds* not observed.

Distribution: North Minahasa District, North Sulawesi.

Geographic distribution: From Philippines to island North Sulawesi (Daniells et al. 2001).

Habitat: cultivated by BPTP (Balai Pengkajian Teknologi Pertanian) Manado.

Altitude: 198 m above sea level.

Utilization: source of fiber for making bags and fishing nets.

Noted: This species originated from Philippines then enter to the Talaud Island and currently is cultivated by BPTP (Balai Pengkajian Teknologi Pertanian) Manado. *M.*

textilis or commonly called abaca banana, is a member of the *Australimusa* section that has long been cultivated because of the usefulness of the stem fiber. This species is different from other species in pseudostem slender and green color with pink-purple blotch, red external and internal red of bract, intermediate male bud with tinted green, and not revolute before falling.

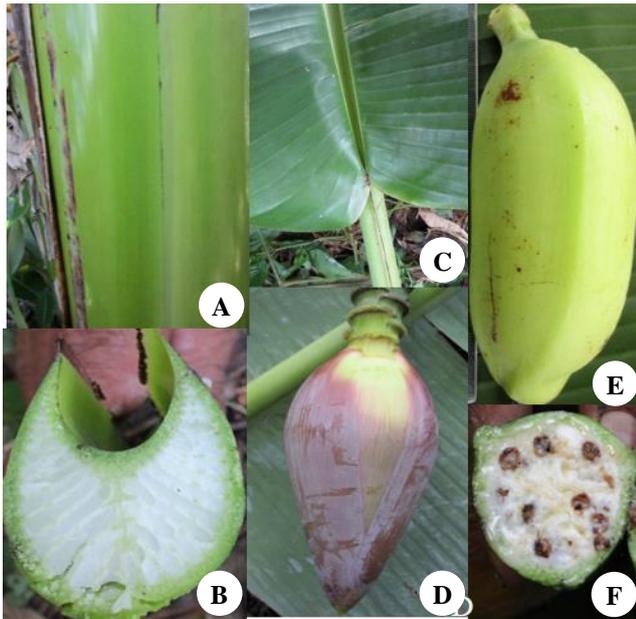


Figure 2. *Musa balbisiana* characters. A. Pseudostem, B. Petiole canal leaf, C. Leaf base, D. Male bud, E. Immature fruit, F. Immature fruit with seed

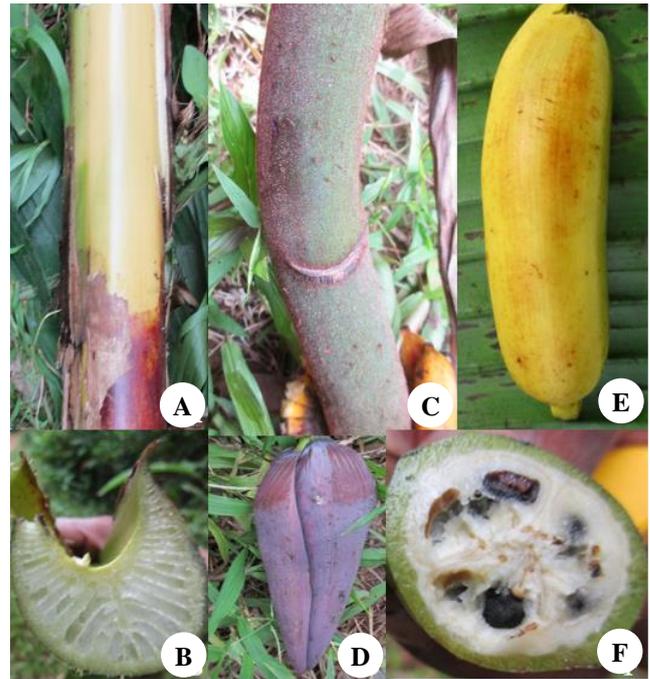


Figure 4. *M. acuminata* var. *lutraensis* character. A. Pseudostem, B. Petiole canal leaf, C. Peduncle, D. Male bud, E. Mature fruit, F. Fruit with seeds

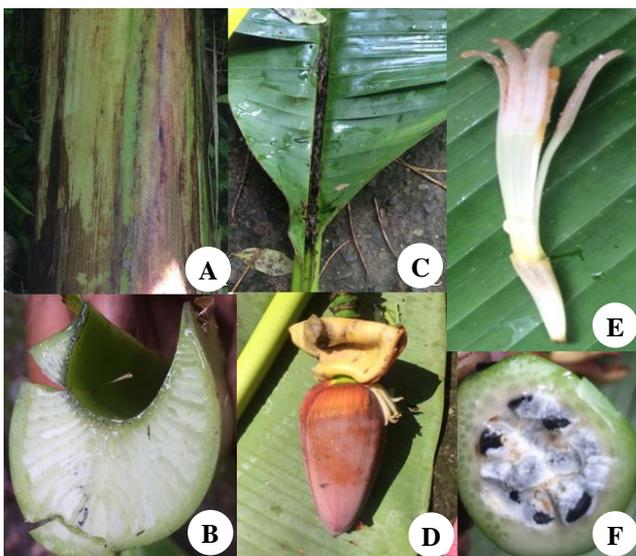


Figure 3. *M. acuminata* var. *zebrina* characters. A. Pseudostem, B. Petiole canal leaf, C. Leaf base, D. Male bud with bract imbrication, E. Male flower, F. Immature fruit with seeds

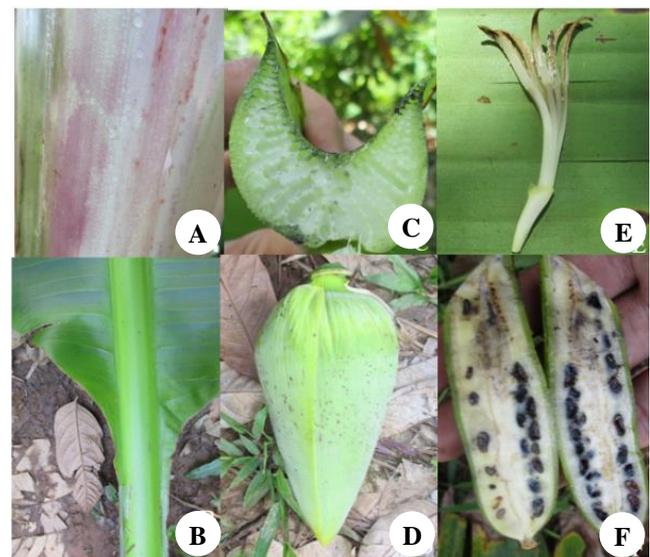


Figure 5. *M. acuminata* var. *banksii* characters. A. Pseudostem, B. Leaf base, C. Petiole canal leaf, D. Male bud, E. Male flower, F. Immature fruit with seed

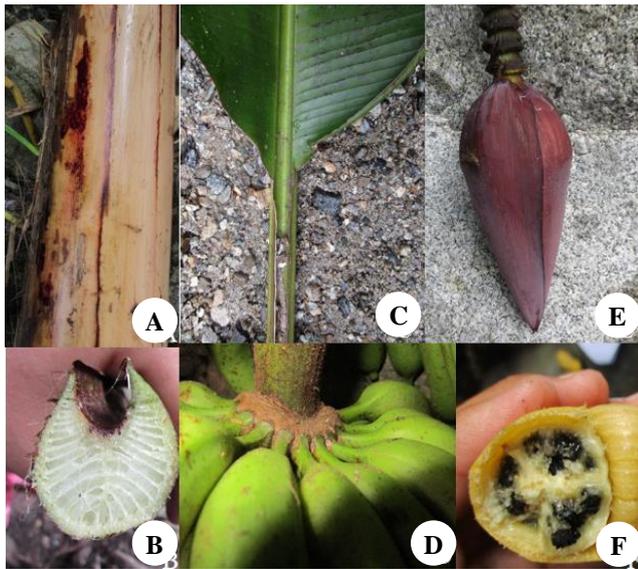


Figure 6. *Musa acuminata* var. *siginensis* characters. A. Pseudostem, B. Petiole canal leaf, C. Leaf base, D. Peduncle and pedicle slightly hairy, E. Male bud, F. Mature fruit with seeds

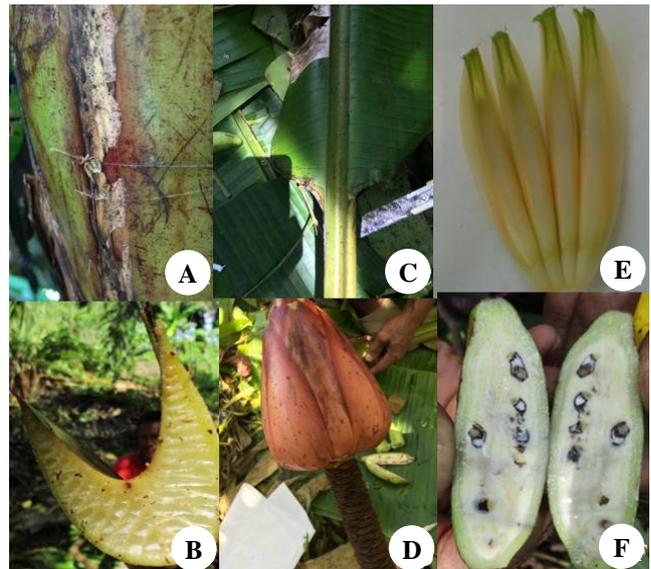


Figure 8. *Musa borneensis* characters. A. Pseudostem, B. Petiole canal leaf, C. Leaf base, D. Male bud, E. Male flower with opaque free tepal, F. Immature fruit with seed

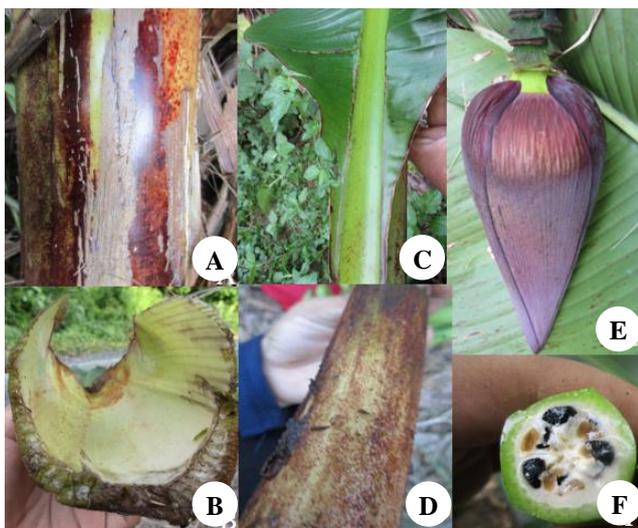


Figure 7. *Musa acuminata* ssp. *microcarpa* characters. A. Pseudostem, B. Petiole canal leaf, C. Leaf base, D. Peduncle, E. Male bud, F. Immature fruit with seeds

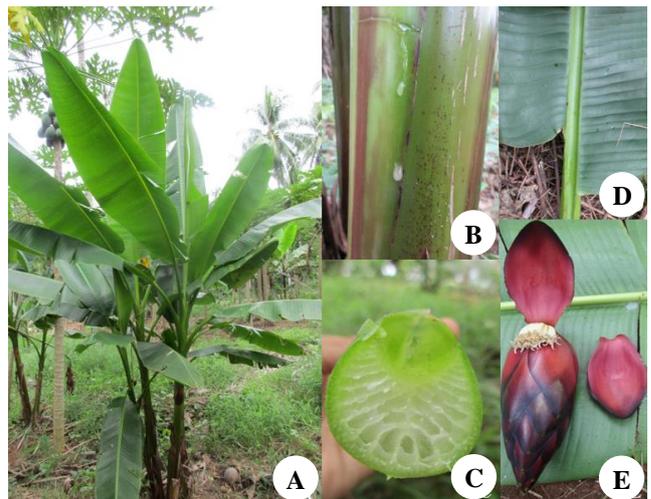


Figure 9. *Musa textilis* characters. A. *Musa textilis* aspect, B. Pseudostem, C. Petiole canal leaf, D. Leaf base, E. Male bud

In general, wild banana species that was found in Sulawesi have been successfully identified but did not have significant economic value for the communities. However, those species could be very valuable for future banana breeding program. Even in some places, the existence of wild bananas is neglected. This will be a threat to the existence of wild bananas in nature, which could lead to reduced gene variation. Collection and conservation effort by relevant agencies need to be carried out immediately so that gene sources can be saved before extinction occurs.

Further research is needed to discover the useful properties of the wild banana species found, and to add to the collection of genetic material for banana breeding programs. Two varieties namely *M. acuminata* var. *lutraensis* and *M. acuminata* var. *sigiensis* are two names given temporarily, to be more convincing whether these two varieties really are of different varieties than those that already exist require additional research such as research at the molecular level.

ACKNOWLEDGEMENTS

We thank Ministry of Research and Technology and Higher Education of the Republic of Indonesia for providing BPPDN scholarships and Doctoral Dissertation Grants for the first authors with contract number 02/PI-LP2M/STKIP-PI/2018.

REFERENCES

- Argent GCG. 1976. Wild Bananas Species of Papua New Guinea. Notes Roy Bot Gard Edinburgh 35: 77-114
- Borborah K, Borthakur SK, Tanti B. 2016. A new variety *Musa balbisiana* from Assam, India. Bangladesh J Plants Taxon 23(1): 75-78.
- Cannon CH. 2005. Vegetation of Sulawesi: fine filter analysis report. Performed as part of the Ecoregional Conservation Assessment. The Nature Conservancy and Texas Tech University, USA
- Cheesman, EE. 1947. Classification of the bananas II. The genus *Musa* L. Kew Bull 2: 106-117.
- Daniells J, Jenni C, Karamura D, Tomekpe K. 2001. Musalogue: A Catalogue of *Musa* Germplasm, Diversity in the Genus *Musa*. INIBAP, Montpellier, France.
- De Langhe E, Vrydaghs L, de Maret P, Perrier X, Denham T. 2009. Why banana matter: An introduction to the history of banana domestication. Ethnobot Res Appl 7: 165-177.
- Hakkinen M, Hong W. 2007. New Species and variety of *Musa* (Musaceae) from Yunnan, China. Novon 17: 440-446.
- Häkkinen M, Meekiong K. 2004. A new species of the wild banana genus, *Musa* (Musaceae), from Borneo. Syst Biodiv 2 (2): 169-170.
- Hakkinen M, Vare H. 2008. Typification and check-list of *Musa* names (Musaceae) with nomenclatural notes. Adansonia 30 (1): 63-122.
- Hakkinen M. 2013. Reappraisal of sectional taxonomy in *Musa* (Musaceae). Taxon 62 (4): 809-813
- Hapsari L. 2014. Wild *Musa* species collection of Purwodadi Botanic Garden: Inventory and its morpho-taxonomic review. J Trop Life Sci 4 (1): 70-80.
- IPGRI. 1996. *Descriptors for Banana (Musa spp.)*. International Plant Genetic Resources Institute, Rome, Italy.
- Janssens SB, Vandercook F, De Langhe E, Verstraete B, Smets E, Vendenhouwe I, Swennen R. 2016. Evolutionary dynamics and biogeography of Musaceae reveal a correlation between the diversification of the banana family and the geological and climatic history. New Phytol 210: 1453-1465.
- Javed MA, Chai M, Othman RY. 2002. Morphological Characterization of Malaysian Wild Banana *Musa acuminata*. Biotropia 18: 21-37.
- Kulkarni VM, Chadha S, SR Yadaf, Dixit GB. 2012. Molecular biodiversity studies in wild and cultivated members of the banana family, Musaceae. CIBTECH J Biotech 1: 4-55.
- Miller RNG, Passos MAN, Menezes NNP, Sousa Jr MT, do Carmo MMC, Azevedo VCR, Amorim EP, Pappas Jr GJ, Ciampi AY. 2010. Characterization of novel microsatellite markers in *Musa acuminata* subsp. *burmannicoides*, var. *Calcutta* 4. Med Central 3: 148-153.
- Mukunthakumar S, Padmesh P, Vineesh PS, Skaria R, Kumar KH, Krishnan PN. 2013. Genetic diversity and differentiation analysis among wild antecedents of banana (*Musa acuminata* Colla) using RAPD markers. Indian J Biotechnol 12: 493-498.
- MusaNet 2016. Summary of the Global Strategy for the Conservation and Use of Musa Genetic Resources (R. Chase and B. Laliberté, compil.). Bioversity International, Montpellier, France.
- Nasution RE, Yamada I. 2001. Pisang-pisang Liar di Indonesia. Puslitbang Biologi-LIPI, Bogor. [Indonesian].
- Nugraha AMS, Hall, R. 2018. Late cenozoic palaeogeography of Sulawesi, Indonesia. Palaeogeogr Palaeoclim Palaeoecol 490: 191-209.
- Perrier X, de Langhe E, Donohue M, Lentfer C, Vrydaghs L, Denham T. 2011. Multidisciplinary perspective on banana (*Musa* spp.) domestication. Proc Natl Acad Sci USA 108: 11311-11318.
- Poerba YS, Martanti D, Ahmad F, Herlina, Handayani T, Witjaksono. 2018. Deskripsi Pisang. LIPI Press. Jakarta. [Indonesian].
- Poerba YS, Martanti D, Handayani T, Herlina, Witjaksono. 2016. Katalog Pisang. LIPI Press. Jakarta. [Indonesian].
- Samarasinghe WLG, Jayaweera SLD, 2008. Occurrence, caharacteristic and diversity wild banana *Musa acuminata* and *Musa balbisiana* in Srilanka. Ann Sri Lanka Dept Agric 10: 165-176.
- Sulistiyarningsih DL, Megia R, Widjaya EA. 2014. Two new records of wild bananas (*Musa balbisiana* and *Musa itinerans*) from Sulawesi. Makara J Sci 18 (1): 1-6.
- Sulistiyarningsih DL. 2017. A newly described and recorded infraspecific taxa of *Musa borneensis* Becc (Musaceae) from Sulawesi Indonesia. Reinwardtia 16 (1): 19-24.
- Sunandar A. 2017. New Record of wild banana (*Musa balbisiana* Colla) in West Kalimantan. Biodiversitas 18 (4): 1324-1330.
- Susandarini R, Subandiyah S, Rugayah, Daryono BS, Nugroho LH. 2013. Assessment of taxonomic affinity of Indonesian pumello (*Citrus maxima* (Burm.) Merr.) based on morphological characters. Amer J Agric Biol Sci 8 (3): 182-190.
- Wallace AR 1869. The Malay Archipelago. The land of the Orang-utan and the bird of paradise. A narrative of travel, with studies of man and nature. Macmillan and Company, London.