

Wild Musa Species Collection of Purwodadi Botanic Garden: Inventory and Its Morpho-taxonomic Review

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ABSTRACT

Indonesia, being part of the center of origin of bananas (Musaceae), has a large number diversity of bananas both wild seeded species and edible seedless cultivated varieties. Inventory of wild Musa species in Purwodadi Botanic Garden has been conducted through compiling data records from PBG's Registration section, field inspection and observation to living collections in the garden, herbarium specimens and literature studies. The results show that total 17 wild Musa accessions has been recorded planted in Purwodadi Botanic Garden since 1990 until 2012; comprises of 8 *Musa acuminata* sub species, 2 *Musa balbisiana* forms, 1 *Musa ornata*, 1 *Musa troglodytarum*, 1 *Musa borneensis* and 4 unidentified species *Musa* spp.; but only 8 living accessions remained in 2012. Morpho-taxonomic review of those 8 wild Musa accessions remained will be discussed in this paper including their geographical distributions. According to its differentiated morphological characteristics observations, it is known that there are three accessions were resembled cultivars and one unidentified species have been determined its species level, so that their registration identity needs to be revised. It is important next to prioritize ex-situ conservation of wild Musa species not yet collected in Purwodadi Botanic Garden especially from Eastern Indonesia.

Keywords: : *inventory, morphological characteristic, wild species, Musa, Purwodadi Botanic Garden*

INTRODUCTION

Indo-Malesian region is considered as the main center origin and diversity of bananas (Musaceae) [1, 2, 3]. Indonesia, being part of the center of origin, has a large number of bananas both edible seedless bananas and wild seeded bananas. Edible seedless bananas mostly grown in the backyards or home gardens whereas wild seeded bananas commonly found in the wild [4]. The genus *Musa* are generally grouped into four sections: Australimusa (n=10), Callimusa (n=10), Rhodochlamys (n=11) and Eumusa (n=11) [5, 6, 7, 8]. Most members of Callimusa and Rhodochlamys are ornamentals in nature; they originated on the Asian continent. Australimusa has 5-6 species, but most important are fibres yielding *Musa textilis* and fruits yielding *Musa febi*, they distribute mostly in Southeast Asia and Pasific

Islands. Eumusa widely distributed in Asia, Africa and South America [9]. One more section Ingenitumusa (n=7), comprised of single species *Musa ingens* Simmonds [10].

In 90's Purwodadi Botanic Garden was the leading botanic garden of its Musaceae collection in South East Asia. The collection reached over 166 numbers, including species, varieties and/or cultivated varieties (mostly cultivated varieties) which were collected through explorations, plants exchanging, grants, community or personal contribution, etc. The first Musa collection was recorded in 1972 [11]. In 2010, its Musa collections there were as many as 119 accessions, 230 specimens, consists of 9 wild species and 110 cultivars [12]. Then by field inspection in early 2012 it decreased become 103 accessions, 197 specimens, 8 wild types and 95 cultivars [13]. These valuable germplasm banks supposed to supply information and propagation materials in support of banana improvement projects of the national research and development systems. Further conservation efforts; an effective monitoring and cultivation management strategy are required to keep this

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Musa germplasms continuously conserved and preserved for future.

The potential uses of wild seeded banana species has not been much explored yet in Indonesia, it is supposed to be linked to its role as germplasms materials for further banana improvements. A vital part of any plant improvement program is the assemblage of germplasm materials that provide sources for resistance genes. The favourite donors are the wild relatives that thrive under adverse conditions. If and when a better variety needs to be improved, the variability will be needed and should be collected, evaluated and used [3, 4, 14]. This paper presents inventory, taxonomic review and differentiating morphological characters of 8 wild *Musa* species living accessions collection of Purwodadi Botanic Garden including its geographical distributions.

MATERIALS AND METHODS

The study was conducted at *Musa* germplasm plots collection of Purwodadi Botanic Garden – Indonesian Institute of Sciences at Area II Vak XXIVA-B-D-E. It is located in a low land dry area of Pasuruan District about 65 km south of Surabaya, East Java, at an altitude of 300 m above sea level, vertisol soil type with the average rainfall about 2366 mm per year.

Inventory of wild *Musa* species records in Purwodadi Botanic Garden were conducted by compiling datas from catalogues records, exploration technical reports, plant collections receipt book and other manuscripts from PBG's registration section also from PBG's herbarium records. The datas compiled including its origins and habitats where the collections were collected including their geographical distributions from references.

Description as well as measurements of the wild *Musa* species living specimens in Purwodadi Botanic Garden were observed and characterized using 'Descriptors for Banana (*Musa* spp.)' published by IPGRI-INIBAP/CIRAD (1996) [15] also documented taken by digital camera. Its differentiating morphological characteristics obtained from field observations then matched with references also herbarium specimens to ascertain its types.

Study to *Musa* herbarium materials were conducted on its particular 'type' species in the Herbarium Bogoriense (BO), Central for Research and Development for Biology, Bogor. Some relevant particular *Musa* specimens collection of Bogor Botanic Garden were also studied. Some

observations and herbarium re-cords have been clearly listed and all those re-ferences are cited where relevant to particular species.

RESULTS AND DISCUSSION

Purwodadi Botanic Garden has been collecting *Musa* germplasms for more than two decades both wild species and cultivated varieties (mostly cultivars). Field inspections on October 2010, its collection remain 111 accessions comprises of 8 numbers of wild species and 103 cultivars. The lost of accessions mostly due to abiotic (drought) and biotic (banana wilts and bunchy top disease) stresses on field [11, 12]. Accessions lost caused by diseases were tendency experienced in banana cultivars than wild species. Wild accessions lost mostly caused by abiotic than biotic stresses. Wild *Musa* species are tending to be more resistant to such diseases, that's what make studies of wild *Musa* species becoming important. Breeding of banana cultivars to some particular wild *Musa* species have resulted some resistant and superior banana clones [1, 4].

Inventory of wild Musa species in Purwodadi Botanic Garden

There are about 37 to 45 species of *Musa* in the world. They are mostly confined to India, Assam, Srilanka, Burma, Thailand, Vietnam, China, probably Japan, Malaysia, Indonesia, Philippines, Papua New Guinea, and Northern part of Australia. In Indonesia alone, there are probably about 9 to 11 *Musa* species [4]. Several plants collecting missions has been conducted by Purwodadi Botanic Garden to ex-situ conserved plants including *Musa* specimens both wild species and native/indigenous unique cultivars especially from Eastern Indonesia.

Records result shows that Purwodadi Botanic Garden have collected and planted 17 accessions of wild *Musa* species since 1990 until today. It comprises of 8 accessions of *Musa acuminata* sub species, 2 accessions of *Musa balbisiana* forms, 1 accession of *Musa ornata*, 1 accession of *Musa troglodytarum*, 1 accession of *Musa borneensis* and 4 accessions of unidentified *Musa* species. By recent direct field inspections in June 2012 noted that there are only 8 living accessions remained (Table 1) which will be reviewed its morpho-taxonomic later.

Musa ornata, *Musa troglodytarum* and *Musa borneensis* recorded has been collected in the garden during 1990-2010 (Table 1). Here are short morpho-taxonomic reviews about them:

Table 1. Inventory list of wild *Musa* species in Purwodadi Botanic Garden

No.	Location	Species	Vernacular name	Origin	Year
1	XXIV.E.40-a	<i>M. acuminata</i> var. <i>flava</i>	<i>P. Jantung Kuning</i>	Tuban, East Java	1990-1999-2007-2010-now
2	XXIV.E.18-ab	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	Pasuruan, East Java	1990-1999
3	XXIV.D.27	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	Sumba, Lesser Sunda Islands	1990-1999-2007-2010-now
4	XXIV.D.30-a	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	Sumba, Lesser Sunda Islands	1990-1999-2007-2010-now
5	XXIV.E.33-a	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	East Java	1990-1999-2007-2010
6	V.D.II.1-a	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	East Java	1990-1999-2007
7	XXIV.D.12-a	<i>M. acuminata</i> var. <i>rutilifes</i>	<i>P. Cici Alas</i>	East Java	1990-1999-2007-2010-now
8	XXIV.D.26-a	<i>M. acuminata</i> var. <i>tomentosa</i>	<i>Unti Darek</i>	South East Sulawesi	1990-1999-2007-2010-now
9	XXIV.D.1-abc	<i>M. balbisiana</i>	<i>Klutuk Ijo</i>	Pasuruan, East Java	1990-1999-2007-2010-now
10	XXIV.B.19	<i>M. balbisiana</i>	<i>Klutuk Wulung</i>	Central Java	1990-1999-2007-2010-now
11	V.D.II.2-a	<i>M. ornata</i>	<i>P. Hias</i>	East Java	1990
12	XXIV.D.49	<i>M. troglodytarum</i>	<i>P. Tongkat Langit, P. Cungit</i>	East Java	1999
13	XXIV.E.66-a	<i>M. borneensis</i>	<i>P. Unkaok, P. Unkadan</i>	Kutai Barat, East Kalimantan	2010
14	XXIV.A.27	<i>Musa</i> sp.	Not available	Solok, West Sumatra	2010-now
15	XXIV.A.28	<i>Musa</i> sp.	Not available	TN. Bukit Barisan, Bengkulu	2010
16	XXIV.B.26	<i>Musa</i> sp.	Not available	Buru Island, Maluku	2010
17	XXIV.A.29	<i>Musa</i> sp.	Not available	CA. Gunung Kentawan, South Kalimantan	2010

Musa ornata Roxb.

Synonyms: *Musa mexicana* Matuda, *Musa speciosa* Ten., *Musa troglodytarum* var. *rubrifolia* Kuntze. Section: Rhodochlamys. Characteristics: Pseudostem slender, 1-3m; leaves oblong or lanceolate from an obtuse or rounded base, green, tinged with violet on the underside of the costa, 60-200 cm by 18-27 cm. Bracts bright violet with a yellowish top, erect peduncle (Figure 1-a). Geographic distributions: Native to South West Asia, Northern India, South India, Himalaya, Myanmar; widespread in cultivation, in Java cultivated as an ornamental at 0-1500 m above sea level [9, 14, 16, 17, 18].

Musa troglodytarum L.

Synonyms: *Musa febi* Bertero ex Vieillard, *Musa seemanni* Mueller, *M. uranoscopos* Miguel. Section: Australimusa. Characteristics: Spurious stem up to 5 m long; leaf light-or dark green, not strongly tillering. Male bud well-developed, fruiting raceme erect or almost. Sap color red-

purple to purple. Fruits large, pulp color ranges from yellow to orange brick-red or red brown, seeds at most 6, often absent, black or brown (Figure 1-b). Geographic distributions: Introduces from the Moluccas, New Guinea, and the Pacific Islands. It distributed throughout the Pacific region, in Indonesia and Polynesia; in Java locally cultivated [16, 18, 19].



Figure 1 Inflorescence of *Musa ornata* collection of Bogor Botanic Garden (a), *Musa troglodytarum* 'type' [Rumphius (1763) in Häkkinen, Väre and Christenhusz (2012)] and male bud of *Musa borneensis* collection of Bogor Botanic Garden (c)

***M. borneensis* Becc.**

No synonyms are recorded. Section: Calimusa. Characteristics: A medium sized species, with densely clustering, slender pseudostems to 3.5 m (12 ft.) tall. The broad corrugated auricles at the region where the petiole joins the sheath are conspicuous and characteristic. Inflorescence horizontally held and later pendulous, with various bract colors from yellow, greenish, pale violet to red-purple. Male bud in advanced blooming is very broadly ovate, with the bracts strongly imbricate. Fruit glabrous, uni-seriate, 14-16 cm. long and 3.5 cm. thick, completely filled with seeds surrounded by very little pulp (Figure 1-c). Geographic distributions: from the tropical lowlands of southern Sarawak on the island of Borneo [18, 19, 20, 21].

Morpho-taxonomic review of 8 living wild Musa accessions

Through observations to its differentiating morphological characteristics of those 8 living Musa specimens revealed that some of them are not true to its type and one species has been determined its species level so that their registration identity needs to be revised by proposing the D6 forms in PBG's Registration section. Accessions number XXIV.D. 26-a (Figure 2-a) was not true to *Musa acuminata* var. *tomentosa*, while XXIV.D.27 (Figure 2-b) and XXIV.D.30-a (Figure 2-c) were not true to *Musa acuminata* var. *rutilifera*, their differentiating morphological characteristics were resembled *Musa acuminata* cultivars, the most prominent is their seedless fruits. Edibility of mature fruits of diploid *Musa acuminata* cultivars (AA) came about as a result of female fertility and parthenocarpy, and such edible types would no doubt have been selected and maintained by humans. Triploid AAA cultivars arose from these diploids, perhaps following crosses between edible diploids and wild *Musa acuminata* subspecies, giving rise to a wide range of AAA genotypes [23].



Figure 2 Inflorescence and seedless fruit of XXIV.D. 26-a (a), Inflorescence of XXIV.D.27 (b) and plant performance of XXIV.D.30-a (c). Those three

accessions were resembled *M. acuminata* cultivars.

One unidentified species (*Musa* sp.) accession XXIV.A.27 have been determined its species level. Its morphological characteristics quite close resembled to *Musa acuminata* var. *alasensis* (Figure 3-a-d, Table 2-A). This accession was derived as a grant from Indonesian Tropical Fruit Research Institute – Solok, West Sumatera in 2001 (P2001104). *Musa acuminata* is the most widespread of the Eumusa species being found throughout the range of the section as a whole. Chromosome structural changes, which have occurred spontaneously, or as a result of recombination events, have resulted in the development of natural reproductive barriers within the species, causing subspecies divergence and genetic diversity in the species as a whole [23]. There are about 15 varieties of *Musa acuminata* species in Indonesia; in Sumatera, five different populations have been successfully recognized; in Java, seven different populations, in Sulawesi one population; while in Molucca and Irian Jaya, only one population has been gathered. They can be found both in lowland and mountainous areas [4].

Characteristic features of *Musa acuminata* species are stems slender with varying development of brown markings; petiole margins erect or spreading; male bud like a top to ovoid, tip acute, purple, orange-red, yellow, or greenish yellow with lanceolate or narrowly ovate bracts; pollen grains many and fertile; fruits in two rows, cylindrical or subcylindrical with acuminate tip, pedicel shorts; seeds irregularly angulate-depressed, black when ripened [1, 4]. Figure 3 and Table 2-A-B-C presents the differentiating morphological characteristics from field observations of *Musa acuminata* varieties of Purwodadi Botanic Garden including *Musa acuminata* var. *alasensis* (XXIV.A.27), *Musa acuminata* var. *rutilifera* (XXIV.D.12-a) and *Musa acuminata* var. *flava* (XXIV.E.40-a).

***Musa acuminata* var. *rutilifera* (Back.) Nasution**

Characteristics: Medium clump, slender pseudostems with brown blotching without wax, short petioles and erect margins, yellowish green leaves and midrib. Male bud shapes like a top to ovoid with bracts purple-yellowish marking at base and few waxes. Fruits small, bottle necked tip, thin peels, yellowish pulp with many seeds (Table 2-b, Figure 3-b-e-f).

Geographical distribution: Central and East Java, on open place or along stream, at 50-1500 m above sea level. In East Java, they are found abundantly in Jolo, at 600-700 m above sea level, it's near to where Purwodadi Botanic Garden lies [4, 14].



Figure 3. Morphological characteristics of *Musa acuminata* varieties: plant performance and inflorescence of *Musa acuminata* var. *alasensis* (a), *Musa acuminata* var. *rutilifes* (b), *Musa acuminata* var. *flava* (c); symmetrical insertion point of blades on petiole with extensive brown blotches at petioles base of *M. acuminata* var. *alasensis* (d); large shoulder bract with orange-red and discontinuing colour towards the base, and creamy male flowers with many fertile pollens of *Musa acuminata* var. *rutilifes* (e); bottle-necked finger tips and yellow ripe fruits of *M. acuminata* var. *rutilifes* (f); open with margin spreading petiole canal leaf III of *Musa acuminata* var. *flava* (g). longitudinal section of bright yellow cracked ripe fruits *Musa acuminata* var. *flava* (h).

***Musa acuminata* var. *alasensis* Nasution**

Characteristics: Extensive brown-dark brown blotching on pseudostems, glabrous peduncle, purplish brown petioles, margins wide and erect with pink midrib (Table 2-A, Figure 3-a-d).

Geographical distribution: growing wild at Alas canyon, Southeast Aceh, on open places along the road between Kotacane and Blangkejeren at 350-1300 m above sea level [4, 14]. Type specimens BO-1297622.

***Musa acuminata* var. *rutilifes* (Back.) Nasution**

Characteristics: Medium clump, slender pseudostems with brown blotching without wax, short petioles and erect margins, yellowish green leaves and midrib. Male bud shapes like a top to ovoid with bracts purple-yellowish marking at base and few waxes. Fruits small, bottle-necked tip, thin peels, yellowish pulp with many seeds (Table 2B, Figure 3-b-e-f).

Geographical distribution: Central and East Java, on open place or along stream, at 50-1500 m above sea level. In East Java, they are found abundantly in Jolo, at 600-700 m above sea level, it's near to where Purwodadi Botanic Garden lies [4, 14].

***Musa acuminata* var. *flava* (Ridl.)**

Nasution

Characteristics: Small to medium clump, pseudostems tall up to 4.7 m high with purplish brown to black blotching without wax. Petioles colour purplish brown blotching with wide erect margins and green midrib. Male bud shapes like a top to ovoid, bracts greenish yellow or yellow colour. Fruits medium, bright yellow peel colour, pulp yellowish with many seeds (Table 2-C, Figure 3-c-g-h).

Geographical distribution: In open places, along the rivers or roads at 300-600 m above sea level, reported found in Central Kalimantan and Malay Peninsula also Pulau Tijau at Pahang River, Malaysia; whereas our collections originated from Tuban, East Java [4, 14, 24].

***Musa balbisiana* Colla**

Characteristics: Herbs 4 – 6.5 height; with robust pseudostem aspect, blotches slight or absent; petiole margin inclosed, not winged below or clasping pseudostem; peduncle perfectly glabrous; ovoid to rounded and imbricate male buds; bracts dark purple with a yellowish top obtuse, dull and waxy at least outside; male flowers variably flushed with pink, cream, pale yellow or pale pink and fruits full of seed berries crowded. It is sometimes cultivated for the leaves which are used for packing merchandise [1, 10, 14, 16, 25]. Geographical distribution: widespread in Southeast Asia, considers it an introduction in Malaysia and Thailand [1, 10, 14, 23].

Musa balbisiana considered to be more drought and disease resistant than *Musa acuminata*, and such characteristics are often found in cultivars containing a 'B' genome [23]. Morpho-taxonomic classification of wild *Musa balbisiana* accessions has led to the identification of seeded BB clones. They are highly tolerant to BBTW, Panama wilt, leaf spot diseases [9].

Musa balbisiana in forms of Pisang Klutuk Ijo and Pisang Klutuk Wulung were mostly differentiated by their pseudostems, petioles and midrib colour, which is dark purple to black for Klutuk Wulung (Figure 4-a-b) while Klutuk Ijo is green (Figure 4-d-e-f). This is in accordance and reflected to their Javanese local names; 'Wulung' means 'Purple' whereas 'Ijo' means 'Green'. Differentiating morphological charac-

teristics of these two forms of *Musa balbisiana* were presents on Figure 4 and Table 2-C-D.

Häkkinen already described 3 varieties of *Musa balbisiana* which he found during several expeditions to China and The Southeast Asia archipelagos i.e. bakeri, dechangensis, liukuensis;

some varieties descriptions still under works i.e. dadugaensis, tombinguangensis and some another undescribed varieties (Personal communications with Häkkinen, 2012). *Musa balbisiana* has exhibited a wide diversity which needs a classification up to subspecies level [9].



Figure 4. Morphological characteristics of *Musa balbisiana*: plant performance and inflorescence of Klutuk Wulung (a), waxy-black-dark purple colour pseudostem, petioles and leaves midribs of Klutuk Wulung (b), finger longitudinal section and ripe hand of Klutuk Wulung (c), plant performance and inflorescence of Klutuk Ijo (d) watery green pseudostem colour and milky sap of Klutuk Ijo (e), both side rounded leaf shape at base and margins overlapping petiole canal leaf III of Klutuk Ijo (f).

Table 2. Differentiating morphological characteristics of (A) *M. acuminata* var. *alasensis*, (B) *M. acuminata* var. *rutilifera*, (C) *M. acuminata* var. *flava*, (D) *M. balbisiana* (Klutuk Wulung) and (E) *M. balbisiana* (Klutuk Ijo).

Description	(A) <i>M. acuminata</i> var. <i>alasensis</i>	(B) <i>M. acuminata</i> var. <i>rutilifera</i>	(C) <i>M. acuminata</i> var. <i>flava</i>	(D) <i>M. balbisiana</i> (Klutuk Wulung)	(E) <i>M. balbisiana</i> (Klutuk Ijo)
Figure	3-a-d	3-b-e-f	3-c-g-h	4-a-c-d	4-b-e-f
Leaf habit	Intermediate	Erect	Intermediate	Intermediate	Intermediate
Dwarfism	Normal	Normal	Normal	Normal	Normal
Pseudostem height (m)	2.1 - 2.9 m	≤ 2 m	≤ 2 m	≥ 3 m (up to 5 m)	≥ 3 m
Pseudostem aspect	Slender	Slender	Slender to normal	Robust	Normal
Pseudostem colour	Green-yellow	Green-yellow	Medium green	Black-dark purple	Green
Pseudostem appearance	Shiny (not waxy)	Shiny (not waxy)	Shiny (not waxy)	Dull (waxy)	Dull (waxy)
Predominant underlying colour of the pseudostem	Cream	Light green	Watery green	Black-green	Watery green
Pigmentation of the underlying pseudostem	Pink-purple	Pink-purple	Purple	Rusty brown	Pink-purple
Sap colour	Pink-red	Milky	Milky	Milky	Milky
Wax on leaf sheaths	Very little or no visible sign of wax	Very little or no visible sign of wax	Very little or no visible sign of wax	Very waxy	Moderately waxy
Number of suckers	2	2 - 5	2 - 5	3 to 6	3 to 6
Position of suckers	Close to parent (vertical growth)	Close to parent (vertical growth)	Close to parent (vertical growth)	Close to parent (vertical growth)	Close to parent (vertical growth)
Blotches at petiole base	Extensive pigmentation	Large blotches	Large blotches	Extensive pigmentation	Without pigmentation
Blotches colour	Brown to Dark brown	Brown	Black-purple	Black-dark purple	Without pigmentation
Petiole canal leaf III	Wide with erect margin	Wide with erect margins	Open with margins spreading	Margins overlapping	Margins overlapping
Petiole margins	Winged and not clasping	Winged and not clasping the pseudostem	Winged and not clasping	Winged and clasping the pseudostem	Winged and clasping the pseudostem
Wing type	Dry	Dry	Dry	Dry	Dry

Petiole margin colour	Light brown	Pink-purple to red	Green	Black-dark purple	Dark purple to black
Edge of petiole margin	With a colour line along	With a colour line along	Colourless (without a colour line along)	With a colour line along	With a colour line along
Petiole margin width (cm)	≤ 1 cm	≤ 1 cm	≤ 1 cm	≤ 1 cm	≤ 1 cm
Leaf blade length (cm)	≤ 150 cm	≤ 150 cm	171 - 220 cm	171 - 220 cm	151 - 170 cm
Leaf blade width (cm)	≤ 50 cm	≤ 50 cm	≤ 50 cm	51 - 60 cm	51 - 60 cm
Petiole length (cm)	51 - 70 cm	31 - 50 cm	51 - 70 cm	51 - 70 cm	51 - 70 cm
Colour of leaf upper surface	Green-yellow	Green-yellow	Green	Dark green with red-purple	Dark green
Appearance of leaf upper surface	Dull	Shiny	Shiny	Shiny	Shiny
Colour of leaf lower surface	Green-yellow	Green-yellow	Medium green	Green	Medium green
Appearance of leaf lower surface	Dull	Dull	Dull	Dull	Dull
Wax on leaves	Very little or no visible sign of wax	Few wax	Moderately waxy	Few wax	Moderately waxy
Insertion point of blades on petiole	Symmetric	Assymetric	Symmetric	Symmetric	Assymetric
Shape of leaf base	Both sides pointed	Both sides pointed	Both sides pointed	Both side rounded	Both side rounded
Leaf corrugation	Very corrugated	Very corrugated	Very corrugated	Very corrugated	Very corrugated
Colour of midrib dorsal surface	Light green	Light green	Green	Green	Light green
Colour of midrib ventral surface	Light green	Yellow	Light green	Green-purple	Light green
Colour of cigar leaf dorsal surface	Green	Green	Green	Red-purple	Green
Blotches on leaves of water suckers	Without blotches	Without blotches	Without blotches	Without blotches	Without blotches
Peduncle length (cm)	≤ 30 cm (18 cm)	≤ 30 cm	≤ 30 cm	31 - 60 cm	31 - 60 cm
Empty nodes on peduncle	3	2	1	3	
Peduncle width (cm)	≤ 6 cm (2.6)	≤ 6 cm	≤ 6 cm	7 - 12 cm	≤ 6 cm
Peduncle colour	Light green	Light green with rusty brown spots	Green	Dark green	Dark green
Peduncle hairiness	Very hairy, short hairs	Hairless	Slightly hairy	Slightly hairy	Slightly hairy
Bunch position	Horizontal	Horizontal	Horizontal	Hanging at angle 45°	Hanging at angle 45°
Bunch shape	Spiral	Spiral	Assymetric	Truncated cone shape	Assymetric
Bunch appearance	Lax	Lax	Compact	Very compact	Compact
Flowers that form the fruit	Hermaphrodite (presence of pollen sacs and pollens)	Hermaphrodite (presence of pollen sacs and pollens)			
Fruits	Biseriate	Biseriate	Biseriate	Biseriate	Biseriate
Rachis type	Present	Present	Present	Present	Present
Rachis position	Falling vertically	Horizontal	Horizontal	At an angle	At an angle
Rachis appearance	Bare	Bare	Neutral flowers (one to few hands)	Neutral flowers (one to few hands only, stalk is bare)	Neutral flowers (one to few hands)

			only, stalk is bare below)	below)	only, stalk is bare below)
Male bud type	Normal (present)	Normal (present)	Normal (present)	Normal (present)	Normal (present)
Male bud shape	Like a top	Like a top	Like a top	Rounded	Rounded
Male bud size (cm)	Diam: 5.1; Length: 12.2	Not observed	Diam: 5.8; Length: 8.2	Not observed	Not observed
Bract base shape	Large shoulder	Large shoulder	Large shoulder	Small shoulder	Small shoulder
Bract apex shape	Slightly pointed	Slightly pointed	Pointed	Obtuse and split	Obtuse and split
Bract imbrication	Old bracts overlap at apex of bud	Old bracts overlap at apex of bud	Old bracts overlap at apex of bud	Young bracts slightly overlap	Young bracts slightly overlap
Colour of the bract external face	Red-purple	Red-purple	Yellow	Red-purple	Purple
Colour of the bract internal face	Red	Orange red	Yellow or green	Red	Red
Colour on the bract apex	Not tinted with yellow	Not tinted with yellow	Colour is uniform yellow until apex	Tinted with yellow	Tinted with yellow
Colour stripes on bract	Without discoloured lines	Without discoloured lines	Without discoloured lines	Without discoloured lines	Without discoloured lines
Bract scars on rachis	Very prominent	Very prominent	Very prominent	Not prominent	Not prominent
Fading of colour on bract base	Colour discontinuing towards the base	Colour discontinuing towards the base	Colour homogenous yellow	Colour homogenous	Colour homogenous
Male bract shape	$x/y < 0.28$ (Lanceolate)	$x/y < 0.28$ (Lanceolate)	$x/y < 0.28$ (Lanceolate)	$x/y > 0.30$ (Ovate)	$x/y > 0.30$ (Ovate)
Male bract lifting	Lifting two or more at a time	Lifting one at a time	Lifting two or more at a time	Lifting two or more at a time	Lifting two or more at a time
Bract behaviour before falling	Revolute	Revolute	Revolute	Not revolute	Not revolute
Wax on the bract	Very few wax	Very few wax	Very few wax	Very waxy	Very waxy
Presence of grooves on the bract	Moderate grooving	Moderate grooving	Moderate grooving	Few grooves	Few grooves
Male flower behaviour	Falling before the bract	Falling before the bract	Falling before the bract	Falling before the bract	Falling before the bract
Compound tepal basic colour	Cream	Cream	Cream	Cream	Cream
Compound tepal pigmentation	Rust coloured spots	Very few or no visible sign of pigmentation	Rust coloured spots	Presence of pink	Presence of pink
Lobe colour of compound tepal	Yellow	Cream	Yellow	Yellow	Yellow
Free tepal colour	Tinted with yellow	Translucent white	Tinted with yellow	Tinted with pink	Tinted with yellow
Free tepal shape	Oval	Oval	Oblong	Oval	Oval
Free tepal appearance	Several folding under apex (corrugated)	Several folding under apex (corrugated)	Several folding under apex (corrugated)	More or less smooth	More or less smooth
Free tepal apex shape	Triangular	Thread-like	Thread-like	Triangular	Thread-like
Anthers exertion	Same level	Exserted	Exserted	Exserted	Exserted
Filament colour	Cream	Cream	Cream	Cream	Cream
Anther colour	Cream	Cream	Cream	Cream	Cream

Pollen sac colour	Brown/rusty brown	Brown/rusty brown	Brown/rusty brown	Cream	Cream to pale brown
Style basic colour	White to cream	Cream	Cream	Cream	Cream
Pigmentation on style	Without pigmentation	Without pigmentation	Without pigmentation	Purple	Without pigmentation
Style exertion	Inserted	Same level	Same level	Same level	Same level
Style shape	Straight	Straight	Straight	Straight	Straight
Stigma colour	Orange	Yellow	Pale orange	Cream to yellow	Yellow
Ovary shape	Arched	Arched	Arched	Straight	Straight
Ovary basic colour	Cream	Yellow	Cream	Cream	Cream
Ovary pigmentation	Very few or no visible sign of pigmentation	Very few or no visible sign of pigmentation	Very few or no visible sign of pigmentation	With red-purple	With red-purple
Dominant colour of male flower	Cream	Cream	Cream	Cream	Cream
Arrangement of ovules	Two rowed	Two rowed	Two rowed	Four rowed	Four rowed
Fruit position	Curved upward	Curved upward	Curved upward	Curved upward	Curved upward
Number of fruits	13-16	≤ 12	≤ 12	≤ 12	13 - 16
Fruit length (cm)	< 10	< 10	10 - 15	10 - 15	10 - 15
Fruit shape	Curved (sharp curve)	Curved (sharp curve)	Curved (sharp curve)	Straight	Straight
Transverse section of fruit	Slightly ridged	Slightly ridged	Rounded	Pronounced ridges	Slightly ridged
Fruit apex	Lengthily pointed	Bottle necked	Bottle necked	Pointed	Pointed
Remains of flower relicts	Base of style prominent	Base of the style prominent	Without any floral relicts	Without any floral relicts	Without any floral relicts
Fruit pedicel length (mm)	≤ 10 mm	≤ 10 mm	11-20 mm	≥ 21 mm	≥ 21 mm
Fruit pedicel width (mm)	5 to 10 mm	5 to 10 mm	5 to 10 mm	> 10 mm	> 10 mm
Pedicel surface	Hairless	Hairless	Hairless	Hairless	Hairless
Immature fruit peel colour	Light green	Light green	Light green	Dark green	Light green
Mature fruit peel colour	Not observed	Bright yellow	Bright yellow	Yellow to orange	Black
Fruit peel thickness	Not observed	Two or less	Two or less	Three or more	Three or more
Cracks in fruit peel	Not observed	Cracked	Cracked	Without cracks	Without cracks
Pulp colour before maturity	White to cream	Cream	Cream	White to cream	White
Pulp colour at maturity	Not observed	Ivory to yellow	Ivory to yellow	Cream to ivory	Cream
Fruits fall from hands	Not observed	Persistent	Deciduous	Persistent	Persistent
Flesh texture	Not observed	Soft	Soft	Soft	Soft
Predominant taste	Not observed	Sugary	Sweet	Sweet and acidic	Sweet and acidic
Presence of seeds with source of pollen	Not observed	> 20	> 20	> 20	> 20
Seed surface	Not observed	Wrinkled	Wrinkled	Slightly wrinkled	Slightly wrinkled
Seed shape	Not observed	Angular (more or less pyramidal)	Angular (more or less pyramidal)	Rounded (but not completely spherical)	Rounded (but not completely spherical)
Seed colour	Not observed	Brown-black	Dark brown	Brown	Dark brown

Deforestation and forests fragmentations has caused major concerns on the lost of genetic resources including *Musa*, so that we have to conserve in *ex situ* collections more for the wild ones

before it finally become extinct. The important role of an *ex situ* conservation of *Musa* germplasm are providing longterm and sustainable conservation of *Musa* genetic resources, main-

taining a source of genetic diversity and related information in the public domain, contributing to better understanding *Musa* diversity through characterization, evaluation and documentation, providing a service for the safe movement of germplasm and related information and developing and transferring *ex situ* conservation technologies [26]. Further conservation efforts; an effective monitoring and cultivation management strategy, including adequate measures or actions to eliminate both abiotic and biotic stresses particularly for the viral diseases are extremely required to keep this *Musa* germplasms continuously conserved and preserved for future.

CONCLUSION

About 17 wild *Musa* accessions have been recorded planted in Purwodadi Botanic Garden since 1990 until 2012 but only 8 living accessions remained in 2012. Through observations to its differentiating morphological characteristics of those 8 living *Musa* specimens revealed that some of them are not true to its type and one species has been determined its species level so that their registration identity needs to be revised. Accessions number XXIV.D. 26-a (Figure 2-a) was not true to *Musa acuminata* var. *tomentosa*, while XXIV.D.27 (Figure 2-b) and XXIV.D.30-a (Figure 2-c) were not true to *Musa acuminata* var. *rutilifes*, their differentiating morphological characteristics were resembled *Musa acuminata* cultivars. One unidentified species (*Musa* sp.) accession XXIV.A.27 have been determined, its morphological characteristics quite close resembled to *Musa acuminata* var. *alansensis*.

Three distinct varieties of *M. acuminata* i.e. *alansensis*, *rutilifes* and *flava*; and two distinct forms of *M. balbisiana* i.e. Pisang Klutuk Wulung and Klutuk Ijo have been reviewed its morpho-taxonomic. The distinguishing characteristics of each variety are shown in Table 2. Deforestation and forests fragmentations has caused major concerns on the lost of genetic resources including *Musa*, so that it is important next to prioritize *ex-situ* conservation of wild *Musa* species not yet collected in Purwodadi Botanic Garden especially from Eastern Indonesia.

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