



# The description, distribution and habitat of wild banana species in northern Viet Nam

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**Abstract** Northern Viet Nam displays a remarkable diversity of wild bananas (*Musa* L.), including the species from which the majority of cultivated bananas derive. The taxonomy and exact distribution of these wild bananas are however not well known, limiting their conservation and use. In the present study, we describe the morphology, ecology, and phytogeography of the 6 *Musa* species that were collected between 2016 and 2019 in northern Viet Nam: *Musa acuminata* Colla, *M. balbisiana* Colla, *M. itinerans* Cheesman, *M. haekkinenii* N.S.Ly & Haev, *M. lutea* R.V.Valmayor, L.D.Danh and Hakkinen and *M. paracoccinea* A.Z.Liu and D.Z.Li. Of these, *M. itinerans* was the species with the most widespread distribution

range, occurring as large mats in various habitats between 136 and 1331 m, whereas *M. acuminata* was found between 136 and 989 m and *M. balbisiana* was between 108 and 981 m. Furthermore, *M. lutea*, *M. paracoccinea* and *M. haekkinenii* were distributed in open areas with low competition for light, between 80 and 800 m. These latter three species have the potential to become ornamental plants, being characterized by bright and colourful upright inflorescences. The data presented here will help in providing a valuable contribution to the conservation and use of the wild bananas in northern Viet Nam.

**Keywords** Morphological characteristics · Musaceae · Northern Viet Nam · Phytogeography

Dang Toan Vu and Tuong Dang Vu contributed equally to this publication.

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## Introduction

Bananas are the most well-known members of the Musaceae Juss., a monocotyledonous family consisting of c. 91 species divided over three genera: *Musa* L. (Linnaeus 1753; Wong et al. 2002) which contain the cultivated bananas, *Ensete* Horan. (Vare and Häkkinen 2011; Horaninow 1862) which contain enset, an important crop in Ethiopia, and monotypic *Musella* (Franch.) H.W.Li. For a long time, the genus *Musa* was organized into four sections based on morphological characteristics and chromosome number: *Eumusa* and *Rhodochlamys* with chromosome number  $2n=2x=22$ , *Australimusa* and *Callimusa* with  $2n=2x=20$  (Cheesman 1947; Franchet 1889; Šimoníková et al. 2022; Wu 1978). Sometimes a fifth section *Ingentimusa* was considered based on the presence of a chromosome number  $2n=2x=14$ . *Australimusa* and *Callimusa* were morphologically defined by having bracts that are heavily imbricated and polished at the abaxial side. *Australimusa* species were delineated from *Callimusa* species by having subglobose or dorsoventrally compressed seeds with a small apical chamber. In contrast, *Callimusa* seeds are cylindrical or barrel-shaped and have large apical chambers (Wong et al. 2002). *Eumusa* and *Rhodochlamys* were characterized by having convolute or imbricate bracts that are rarely or never polished. Members of the *Eumusa* section are characterized by having dull-coloured bracts, often being more than three meters high, generating several flowers per bract, whereas members of the *Rhodochlamys* section are always less than three meters high with upright inflorescences, only a few flowers per bract and bright coloured bracts. Both the sections *Eumusa* and *Callimusa* are represented in Viet Nam. Later, (Wong et al. 2002) argued that sections *Eumusa* and *Rhodochlamys* should be merged into a single Section ( $2n=2x=22$ ) and that the *Australimusa* section should be included in an enlarged *Callimusa* Section ( $2n=2x=20$ ). In 2013, Häkkinen carried out a thorough revision of the *Musa* sections and decided to confirm this reorganisation (Häkkinen 2013). Moreover, Häkkinen (2013) estimated the number of species in the *Musa* genus at around 70 of which 33 species belonged to the *Musa* section and 37 species to the novel *Callimusa* section. However, this list has many synonyms and homonyms and needs to be

further optimized from a taxonomic and systematic perspective.

Wild bananas provide an important source of important alleles for banana crop improvement. Wild *M. acuminata* Colla and *M. balbisiana* Colla germplasm have been used for breeding novel varieties that cope better with pests and diseases and for the improvement of important agronomic features including yield (Laliberte and De Langhe 2016). In addition, *Musa basjoo* Siebold and Zucc. Ex linuma, *M. thomsonii* (King) A.M. Cowan and Cowan, *M. sikkimensis* Kurz have been investigated for use in breeding cold-tolerant bananas, while *M. balbisiana* and *M. nagensium* Prain were examined for drought tolerance improvement (Horry and De Langhe 2016; Rosales et al. 2006). With the recent detection of *Fusarium oxysporum* f. sp. *cubense* tropical race 4 (TR4) in Colombia and more extreme weather events associated with a changing climate, studying and conserving wild bananas could become even more important (García-Bastidas et al. 2019).

Viet Nam is geographically located in Indochina, one of the world's main centers of biodiversity (Myers et al. 2000), wild bananas included (Le Dinh Danh et al. 1998). A total of 9 *Musa* species have been identified in Viet Nam (Supplementary material S1). All these species have been verified and accepted by Häkkinen and Väre (2008), and in addition by (Lý Ngọc Sâm et al. 2018) for *Musa splendida* A.Chev.

Despite this large number of species, *Musa* remains an understudied genus. This is partly caused by too large difficulties in preparing valuable herbarium specimens that can be used for further taxonomic and systematic research (Gagnepain et al. 1907; Venu 2002). As a result, there are therefore many inconsistencies in the general taxonomy of *Musa* as well as correctly identifying wild banana accessions. In northern Viet Nam in particular there is insufficient data about the morphological characterization and distribution of wild bananas making it difficult to get a correct overview of the extent and diversity of this important group. In order to improve our knowledge of wild bananas in this important region, multiple field trips were undertaken between 2016 and 2019 to document wild *Musa* species of northern Viet Nam. In the current paper, we revise the wild *Musa* species from northern Viet Nam, improve their distribution data, and optimize the overall taxonomic description of those wild *Musa* species.

## Materials and methods

### Collections

Twelve collecting trips were carried out between 2016 and 2019 in 27 districts of nine provinces in the north of Viet Nam. We determined putative sites to locate wild *Musa* species based on earlier reports, and geographic and habitat data (Häkkinen and Väre 2008; Le Dinh Danh et al. 1998; Lý Ngọc Sâm et al. 2012; Lý Ngọc Sâm et al. 2018; Phạm Hoàng Hộ 1999; Valmayor 2001; Valmayor et al. 2004; Valmayor et al. 2005). In each district, local authorities were contacted for data at the district and commune level on geographic terrain and elevation, forest ecology and *Musa* population locations. Additionally, at the commune level, local people well acquainted with wild banana populations (e.g. rangers, farmers and foresters) assisted in identifying specific survey locations. For each located population, we recorded longitude, latitude, and elevation using a Garmin GPS (Garmin eTrex 10; Garmin Ltd. Kansas USA). As wild bananas were often found in densely covered forests or deep valleys and for which GPS signals are often weak or only moderately accurate, we fine-tuned collection localities using Google Earth or Google Maps.

### Documentation of morphological characters

For each species and population collected, specimens were characterized by recording 34 morphological characters (descriptors) as defined by the Taxonomy Advisory Group (TAG) (revised 2019). These included vegetative elements (size, shape, and colour of the pseudostem, leaf, petiole and rachis), inflorescences (shape, and colour of the male bud, male bud size, bract shape, tepals, and anthers), and fruit (number of hands per bunch, fruits per hand, fruit length, fruit shape, fruit apex and fruit pedicel). Measurements of pseudostem and inflorescence size were carried out on five plants per species. Additionally, we took at least fifteen pictures of each specimen from every population collected, showing the most important descriptors according to TAG (revised 2019). Colours were also determined using the TAG colour chart (revised 2019), out of direct sunlight and scored to the closest colour using freshly collected material. In order to identify the species name of each sample,

we compared our observations with morphological keys from the literature (Daniells et al. (2001); Häkkinen and Väre (2008); OECD (2010).

Furthermore, the participatory research appraisal tools such as direct observation, interviews, and field visiting were applied in collecting traditional knowledge of wild bananas (Shuaib et al. 2021; Vu and Nguyen 2017). The traditional knowledge included local names, ecological distribution, and plant usages such as edible and/or medicinal usage, following the method of Fontefrancesco et al. (2022), Abidullah et al. (2021), Shuaib et al. (2021), Tongco (2007).

### Sampling methodology

Mature fruits and seeds were collected from each examined population. Seed maturity was assessed by conducting a cut test (we regarded seeds as mature when having a powdery dry starch endosperm). Seeds were cleaned from the surrounding endocarp in the laboratory after the collecting trip with water and subsequently dried under a fan. Then, seed samples were dried to 15% equilibrium relative humidity (eRH) and tested daily with a hygrometer. Further seed drying was achieved at a slow rate using equal silica gel to seed mass. Finally, seed samples were sealed in aluminum bags and stored at  $-20^{\circ}\text{C}$  for long-term storage (Guarino et al. 2011; Hay and Probert 2013; Liu et al. 2020). Samples were duplicated for storage at the Millennium Seed Bank (Royal Botanic Garden, Kew, UK) and Plant Resources Center (Ha Noi, Viet Nam).

Additionally, within each population, fifteen to twenty leaf samples were collected from different individuals. Leaf samples were taken from a small part of the second leaf after the cigar leaf and were subsequently cleaned with a cloth and put in a tea-bag. After that, the tea bags containing leaves were placed in sealed plastic bags containing silica gel to desiccate samples quickly (Wilkie et al. 2013). Dry leaves were stored for long-term storage in sealed bags without silica gel. Leaf samples were transferred to Meise Botanic Garden (Belgium) for storage and DNA extraction.

### Specimen preparation

A herbarium specimen was made representing each population. Specimens included leaf base and apex,

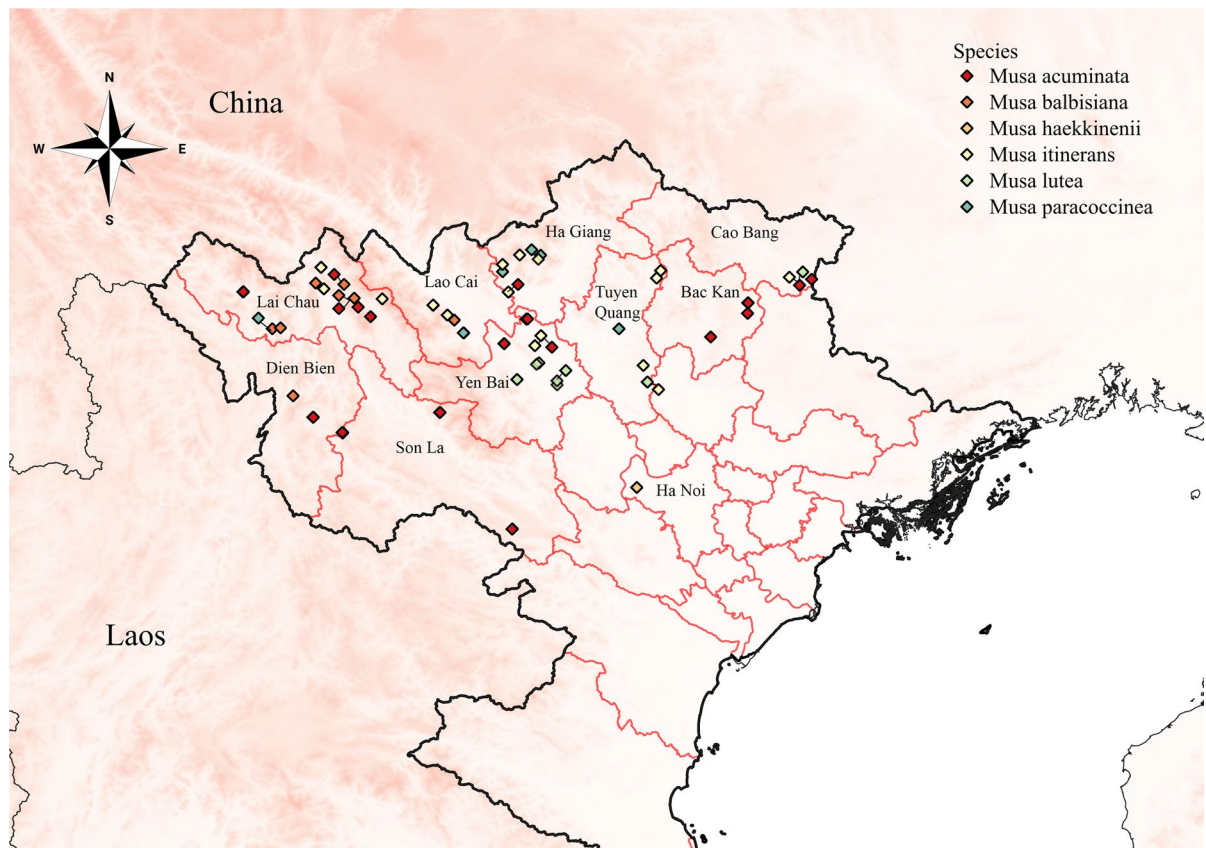
inflorescence bracts, flowers, and fruits. During the collection trip, all material was stored in a solution of 70% ethanol by volume. Immediately after the field trip, the collected material was cleaned and dried in a plant press. All herbarium samples were placed between thick, water-absorbing paper and put in a drying-oven at 45 °C for four days (or more). Due to the large size of plant parts, we often collected only the base and apex of mature leaves. In case we were able to collect full leaves, they were folded to fit the herbarium sheets. Fruits, collected for herbarium specimens, were longitudinally sliced in half (Davis update 2011; Queensland herbarium 2016). Herbarium vouchers were divided between the herbarium of Royal Botanic Gardens, Kew (KEW) (United Kingdom) and Plant Resources Center (Ha Noi, Viet

Nam). Vouchers of 6 species were deposited in the HNU Herbarium of Vietnam National University of Science (Table 2).

## Results

### Distribution and topography of survey sites

Wild bananas were surveyed and collected between 2016 and 2019 in nine provinces situated in the northern climate type (Fig. 1). Field trips for *Musa* collections were made in the climatic subzones as defined by Van (2015) and summarised in Supplementary Table 2. These embrace ten of the 18 delineated northern Vietnamese habitat types defined by Lung



**Fig. 1** The distribution of 6 species on the map (Symbol colours specify the species found at each location). The map was created using QGIS 3.14 (QGIS Development Team 2020). Geospatial data used for the creation of this map include international (QGIS Development Team 2020) and subnational

(QGIS Development Team 2020) administrative boundaries, distributed under ODC-ODbL and CC BY-IGO licenses respectively. The white to dark-red shaded background represents elevation, retrieved from The World Bank (2020), distributed under a CC-BY 4.0 license)



et al. (2011) and summarised in Supplementation Table 3.

Seeds and leaf tissue were from a total of 80 populations of six different banana species, *Musa balbisiana* (14), *M. acuminata* (19), *M. itinerans* (26), *M. paracoccinea* (14), *M. lutea* (6), and *M. haekkinenii* (1) (Table 2).

#### *Descriptions of species collected*

The original description by the authors who established the species status is compared with those observed by the team. Additional descriptors are formulated as in the “Minimum List of Descriptors for Musa” (Taxonomy Advisory Group (TAG) 2019).

*Musa balbisiana* Colla: Colla, Memorie della Reale Accademia Delle Scienze di Torino 25: 56-57, 1820b; Cheesman, Kew Bull. 3(1): 11-17, 1948; Jacob, Superintendent Government Press, 1952; Joe et al., 2014, Phytotaxa, 175(2), 113-116; Simmonds, Longmans, 1962; Simmonds, Longmans, 1966; Singh et al, Malay. Nat. J. 52 (3 & 4): 157-160, 1998; Wu, D.L. & Kress, W.J. Fl. China 24: 314-318, 2000; Nayar, N.M., Horticult Rev 36: 127-129, 2010; Kongkona Borah et al, Indian J. Tradit. Knowl, 15 (1): 116-120, 2016.

**Type:** India orientalis, ex H. Rip. 1820 *Anonymous* (lecto designed by Häkkinen and Väre: TO, n.v.).

**Description** Pseudostem is to 6 m in height and grows in clusters, large in size, green coloured below when leaf sheaths are removed (Fig. 2c). Blotch at petiole base is not pigmented, the petiole light green with wax, petiole canal of third leaf margins curved inward, petiole margin not winged; clasp, green and rim contrasts with the petiole (Fig. 2d, and e). Leaves are slightly yellowish-green on the upper surface; base cordate, asymmetrical (Fig. 2o). Cigar leaf green.

Peduncle hairless; bunch and male rachis hang vertically, could be 2.5 m long, bunch cone-shaped. Male rachis has male bracts above the male bud, the rest of the stalk can be bare. Male bud has a skinny shape, a medium length between 20 and 30 cm and a low shoulder. The bract of the male flowers has an obtuse shape, moderate imprecation, last lifted bract does not revolute; bracts of female flowers deciduous after female flower becomes fruit, bract has a

red-purple external with adaxially yellow-green; internal red (Fig. 2h, i and j). Compound tepals turn from pink-purple to bright yellow in lobes of compound tepal (Fig. 2i, and k), anthers yellow.

Bunch has 8–10 hands (Fig. 2g), each hand 8–20 fruits (Fig. 2m). Fruit length 5–10 cm, obovoid and slightly curved. The fruit apex is pointed with persistent flower relicts. Fruit pedicel length more than 21 mm and no visible sign of fusion (Fig. 2m, and n). Seeds numerous, brown, oblate, creased shells (Fig. 2n).

**Distribution:** *Musa balbisiana* populations, fourteen in total, were found in north-western regions. Figure 1 shows the locations where they were collected. The altitude range of the collection areas was 108–959 m.

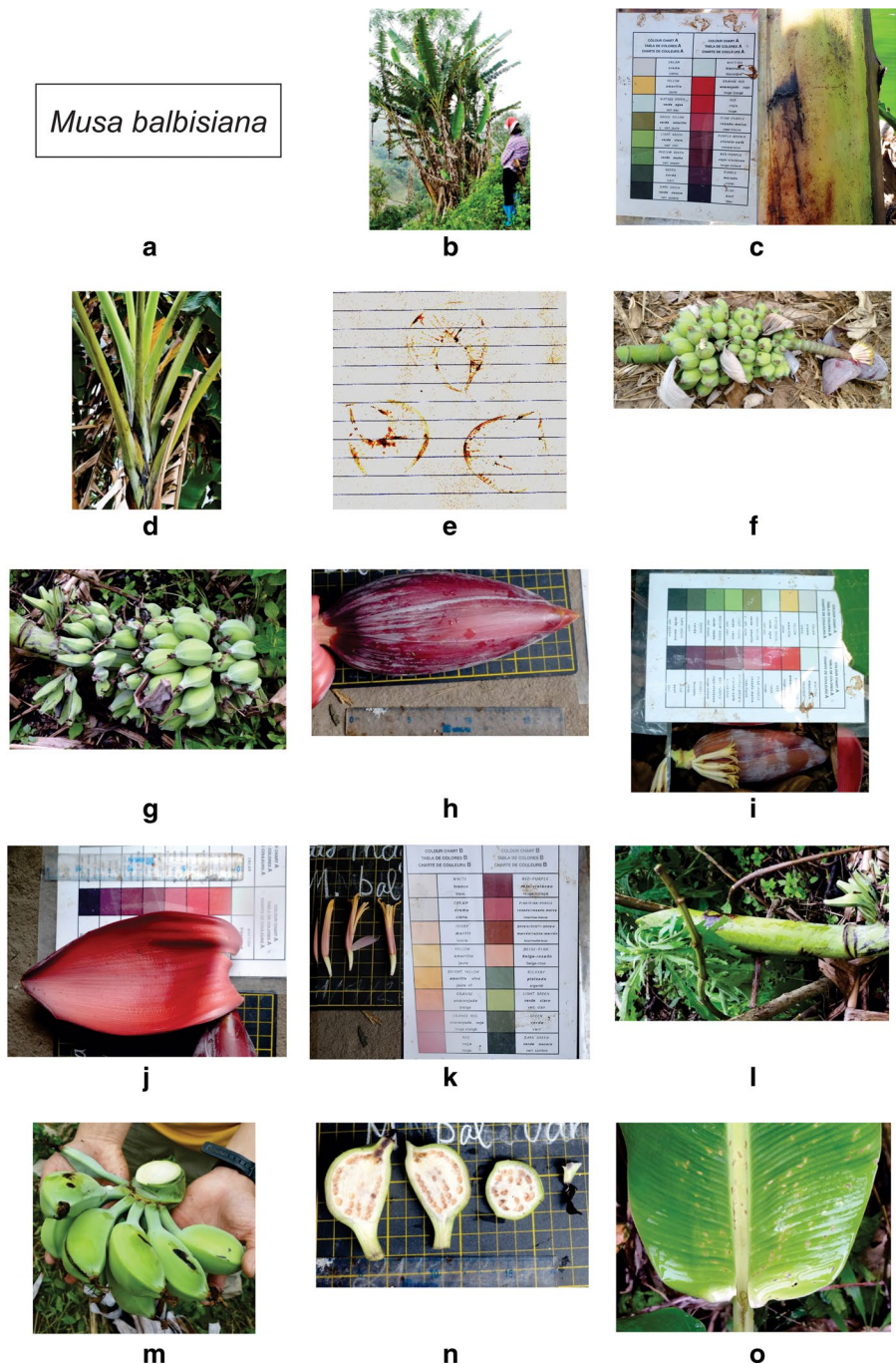
**Habitat:** *Musa balbisiana* often occurs on cleared hill slopes that are regenerating from earlier clearing activities. In this habitat, shrubs and grasses are growing and the species do not compete for light with other large and tall trees. *Musa balbisiana* often occurs as sizeable populations that dominate over large areas.

*Musa balbisiana* was initially considered to be found throughout the whole of Viet Nam (Le Dinh Danh et al. 1998). However, collection teams only discovered wild forms of *M. balbisiana* in the north-west of Viet Nam. Le Dinh Danh et al. (1998) also showed *M. balbisiana* has three forms: 1) wild, diploid, with many seeds (BBw) with the name Chuoi hot rung; 2) seeded but seeds less numerous and soft, with the name Chuoi hot; 3) edible, seedless, triploid and cultivated (BBBc) with the name Chuoi hot qua lep. Form two and three were also found in collection areas, but they were not focused on in this study that dealt with wild Vietnamese *Musa* species.

Of the fourteen *Musa balbisiana* populations found in northern Viet Nam, 11 occurred in the tropical monsoon climate range characterized by dry, cold winters, always below 700 m altitude. There, the annual average temperature is low in comparison with other climatic zones. This region is characterized by relatively high precipitation (rainfall, rainy season). The indicators for the dry season are ranging of dry and drought months. The other three populations of *M. balbisiana* were located above 700 m in elevations

**Fig. 2** *Musa balbisiana* Colla: **a** label, **b** entire plant, **c** pseudostem under-layers, **d** neck, **e** petiole canal, **f** bunch and rachis, **g** bunch close-up, **h** male bud, **i** bract internal colour and flowers, **j** bract shape, **k** flower with colour of the anthers, **l** peduncle close-up, **m** hand, **n** fruits, **o** other photos (optional)

### *Musa balbisiana*



belonging to the Hoang Lien Son sub-climate region (Supplementary Table 2) (Van 2015).

**Conservation status:** *Musa balbisiana* is conserved ex-situ at Plant Resources Center (Ha Noi, Viet Nam). IUCN conservation assessment of the

species showed that it is the Least concern (Allen 2019).

**Local names:** In Viet Nam, most ethnic groups have a specific vernacular name for *Musa balbisiana*. These include: cuối peng (Tây language), chịu

píu (Dao language), trơ cò (Mông language), chi đòng (Giáy language), and pè dón (Kháng language) (Table 2). The species is also known as Chuoi hot rung, meaning jungle banana with seeds, in the Kinh ethnic language.

*Musa acuminata* Colla: Mem. Reale Accad. Sci. Torino 25:394, 1820a; Zoll. Kurz. J. Agr. Hort. Soc. India 5: 112-168, 1878; Koorder Exk. Fl. Java 314, 1911; ibid. Fl. Tjibodas, Visser, Batavia 52-53, 1913; Cheesman, Kew Bull. 3(1): 17-28, 1948; Simmonds, Bot. J. Linn. 55(359): 302-312, 1955; ibid; Evol. Banana, 1962; Backer & Bakhuizen, Jr. Fl. Java 3: 35-38, 1968; Itino et al, Biotropica, 23(2): 151-158, 1991; Vrydaghs et al, Ethnobot. Res. Appl., 7: 239–246, 2009; Hastuti et al, *Biodiversitas* 20(3): 824-832, 2019.

**Type:** Rumphius (1747), Herbarium Amboinense 5: t. 61 Fig. 1, *M. simiarum* Pissang Jacki.

**Description:** The morphology of all the observed plants completely conform to the description of the type by Cheesman (Fig. 3).

Pseudostem about 3 m in height, cream coloured below when leaf sheaths are removed (Fig. 3c). Plants grow in clusters or clumps, often growing separately. Blotch at the petiole base is brown and moderate and black–purple, petioles are usually light green with wax on the back, the petiole canal of the third leaf margins spreads (Fig. 3e), petiole margin not winged and clasped, green and rim contrast with the petiole (Fig. 3d). The leaves are dark green without wax on the upper surface, lighter green colour and wax on the lower surface; base oblique (Fig. 3o). Cigar leaf green.

The peduncle is short-highly hairy (Fig. 3g); the bunch is often hung at about 45° angle, but the male rachis sometimes hangs horizontally; bunch cylindrical to truncate shape but very short (Fig. 3g), male rachis bare. Male bud has a skinny shape, a medium length between 20 and 30 cm, and a low shoulder (Fig. 3h, and i). The bract apex of the male flowers has an intermediate shape, moderate imprecation and last lifted bract revolute before falling; the bract of the female flower is purple and waxed externally, adaxially yellow-green, internally purple (Fig. 3h, i and j). Compound tepal turns from

yellow to bright yellow in lobes (Fig. 3d, and e), anther brown-rusty brown.

Bunch has 10–15 hands, each hand has 10–30 fruits (Fig. 3g and m). Fruit length 5–10 cm, curved. Fruit apex has bottle-neck without reflects. Ripe fruits are yellow, often browned by insects or other lesions on the skin, with a strong aroma. Fruit pedicel short length, 5–10 mm, and no visible sign of fusion (Fig. 3m, n).

The species is subdivided in subspecies (Simmonds 1956b), and we identified all the examined *acuminata* specimens as belonging to his subspecies *siamea*. However, confusion may occur because of the male bud which strongly reminds that of the ssp. *burmannica*, and an explanation is necessary here.

Figure 3h, and i shows the bracts that are characteristic for the ‘Annam form’ described by Cheesman (sub-Indo-China), i.e. “male bud...indistinguishable in all respects from the bud of the Tavoy form (later on named by Simmonds (1956a, b, p468) subspecies *burmannica* (Simmonds 1956a), the latter having ‘bracts dark violet–purple’” (same page, subspecies Burma).

Simmonds, in his “Botanical results of the banana expedition, p 467” included the Annam form in his subsp. *siamea*, but together with the ‘Kedah form’ which in fact closely resembles subspecies *malaccensis* with its reddish purple bracts at their outside. This apparently led Simmonds to state that “This subspecies (*siamea*) is, in general aspect, nearest to the subsp. *malaccensis*”, with the result that he described the subspecies *siamea* male bud as having “bracts paler, more purple in tone”.

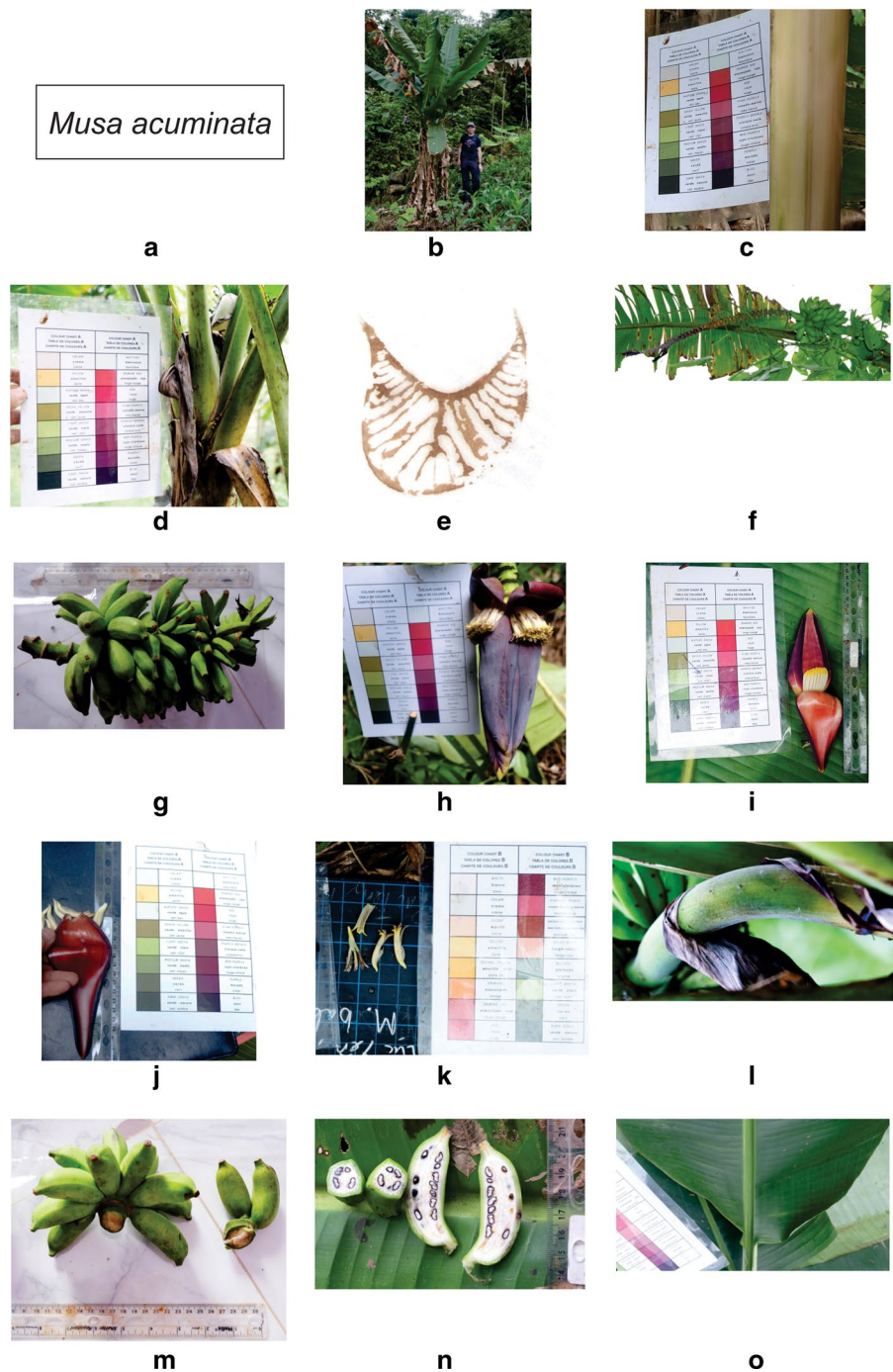
With the hope that the taxonomy of subspecies *siamea* will be definitely clarified in the future, we meanwhile adopt for our specimen the name “*M. acuminata* subsp. *siamea*, form Annam”.

**Distribution:** A total of 18 populations of *M. acuminata* were found in northwestern and northeastern provinces. Figure 1 shows the locations where they were collected. The altitudinal range of the collected *M. acuminata* accessions was between 137 and 989 m.

**Habitat:** *Musa acuminata* often grows on fertile, loose land, that is usually characterized by wet brown soil. This species was also found in gaps in the soil or alongside large rocks covered with a thin layer of soil.



**Fig. 3** *Musa acuminata* Colla: **a** label, **b** entire plant, **c** pseudostem under-layers, **d** neck, **e** petiole canal, **f** bunch and rachis, **g** bunch close-up, **h** male bud, **i** bract internal colour and flowers, **j** bract shape, **k** flower with colour of the anthers, **l** peduncle close-up, **m** hand, **n** fruits, **o** other photos (optional)



In contrast to Le Dinh Danh et al. (1998), who only found *M. acuminata* in the south of Viet Nam, we also collected it in many northern provinces (Table 2).

We found *Musa acuminata* in fairly wide distribution range, covering all subclimate-regions of

Supplementary Table 2 (Van 2015), and seven forestry ecological sub-regions as indicated in Supplementary Table 3 (Lung et al. 2011).

**Conservation status:** *Musa acuminata* is conserved as ex-situ collection at Plant Resources Center



(Ha Noi, Viet Nam). IUCN conservation assessment of the species showed that the species is the Least concern (Williams 2017).

**Local names:** In Viet Nam, vernacular names for this species include cuồi cây (Nùng language), thiú chây (Dao-long shirt language), cuồi peng (Tày language), giuốc năng (Dao, Tày, Nùng language from Cao Bang province), chiu piu gâi (Dao from Lai Chau province), tfawp quav tfhws/ tróp qua trù (written in Mông language/read in Kinh language), chi đòong (Giáy language) and cộ vén or cuồi pá (Thái language) (Table 2). According to (Le Dinh Danh et al. 1998), it is also known as Chuoi tay rung.

***Musa itinerans* Cheesman:** Cheesman, Kew Bulletin (1):23-28, 1949; Simmonds, Kew Bulletin 11(3):463-489, 1956; Stover & Simmonds, Longman Sc & Tech, 1987; Novak, CAB International, 449-488, 1992; Liu, Bot. Bull. Acad. Sin. 43(1):77-81, 2002; Valmayor & Hakkines, Philipp. Agric. Sci. 88(2):236-244, 2005; Häkkinen, *Novon* 18: 50-60, 2008; Sulistyaningsih et al, *Makara J. Sci.*, 1-6, 2014.

**Type:** [Myanmar] Burma, Myitkyina, Tagwin, alt. 400 ft, evergreen forests, C. E. Parkinson 1761, designated by Liu et al. [2002: 79] “lectotype”).

**Description:** Cheesman (1949) description fits with the observed populations for the basic descriptors (Fig. 4).

Pseudostem about 3–7 m high, and up to 12 m in some populations, growing separately, with long rhizomes far from the mother plant. Pseudostem diameter 20–25 cm or larger in some populations at the base; with cream, yellow, purple-brown, or red–purple colour under layers. Blotches of the petiole base are moderate, purple-brown to black-purple, the petiole green to yellow without wax, petiole canal of the third leaf margin erect (Fig. 4e), petiole margin not winged and clasped, purple to blue colour and rim contrast with the petiole (Fig. 4d). The leaves are dark green on the upper surface, lighter green colour and without wax on both the face; base subcordate, asymmetrical (Fig. 4o). Cigar leaf light red–purple.

The peduncle is slightly hairy, bunch and male rachis hang from a slight angle to about 45°, bunch cylindrical, male rachis bare. The male bud has

a small to medium shape, medium to fat size, and low shoulder. Bract of male flowers has an obtuse, convolute imbrication, and last lifted bract revolute; bract has a red–purple colour external face (some populations have yellow-green with purple-brown streaks, yellow or red colour) and yellow colour internal face (Fig. 4h, i, j). Compound tepal has yellow with bright yellow lobe (Fig. 4k), anther bright yellow.

Bunch has 5–10 hands up to 15 hands (Fig. 4c), each hand with 10–20 fruits (Fig. 4m). Fruit length 7–12 cm, slightly curved, fruit apex pointed without relicts; pedicel fruit has 30–70 cm length and partial fusion (Fig. 4m, n).

**Distribution:** A total of 24 populations of *Musa itinerans* populations were found in the northwestern and northeastern provinces (Fig. 1 and Table 2). Populations of the species were collected between 136 and 1331 m.

**Habitat:** *Musa itinerans* is found in green forests and valleys that are characterized by a high degree of humidity, often near water sources. They grow most often in large populations when there are no large trees in the close vicinity.

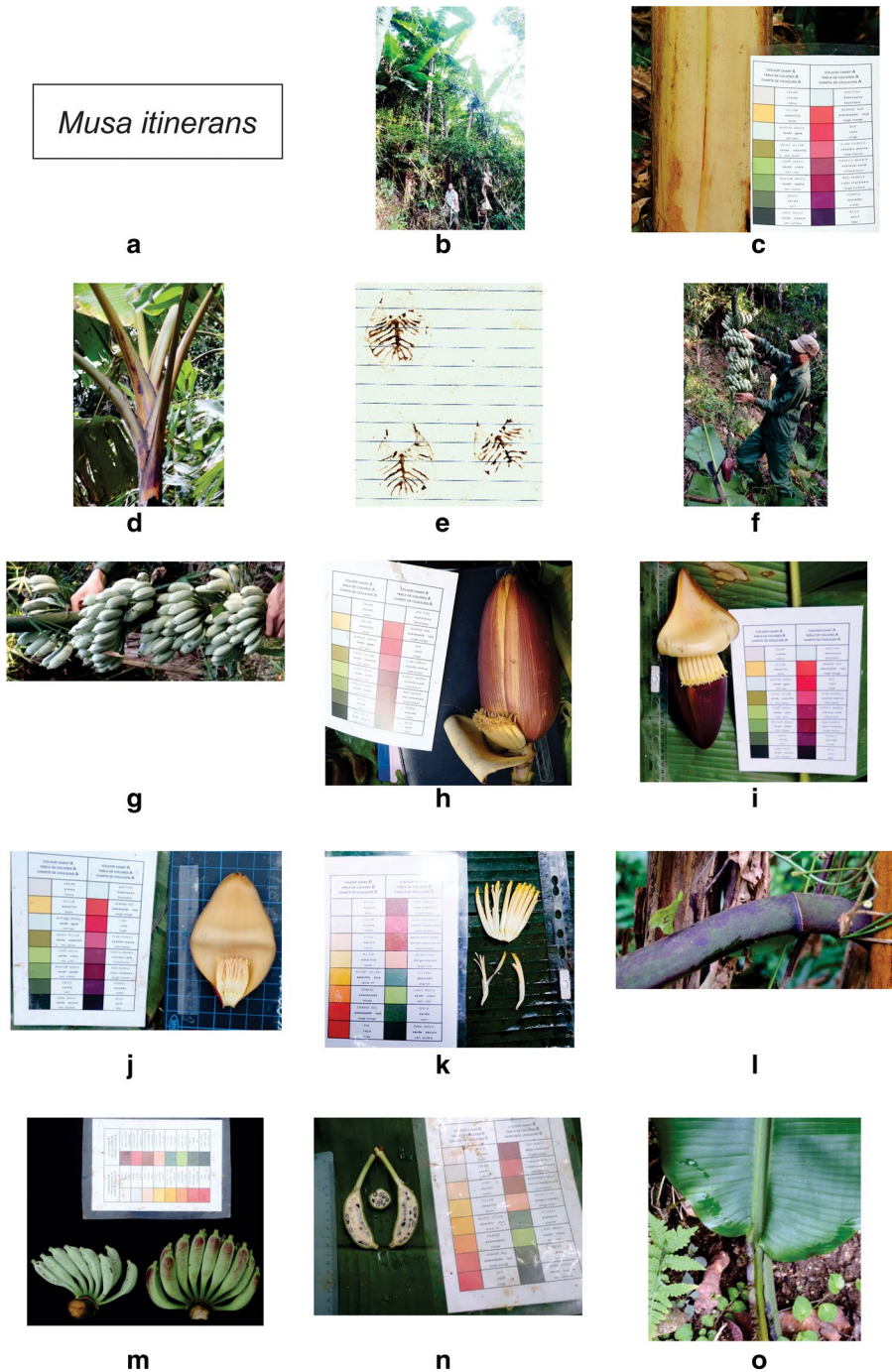
*Musa itinerans* is found throughout the whole country (Le Dinh Danh et al. 1998). Likewise, we also collected the species in many parts of northern Viet Nam (Table 2). Populations were distributed in a wide topographical range in three of the five Vietnamese climate regions, and in nine of the 18 ecological subregions of northern Viet Nam.

**Conservation status:** *Musa itinerans* is conserved as ex-situ collection at Plant Resources Center (Ha Noi, Viet Nam). A conservation assessment of the species by Mertens et al. (2021) showed that the species is Least Concern (LC).

**Local names:** In Viet Nam, the vernacular names for this species are chuối tím or chuối quả tím (Kinh language), cuồi suộc (Nùng language), thiú ui tung (Dao-long shirt language), cuồi lộc (Tày language), cuồi pá or cuồi tang (Thái language), giuốc đống (Dao, Tày, Nùng language in Thạch An district, Cao Bang province), tfawp laib/tróp lia) (written in Mông language/read in Kinh language) (Table 2).

**Fig. 4** *Musa itinerans* Cheesman: **a** label, **b** entire plant, **c** pseudostem underlayers, **d** neck, **e** petiole canal, **f** bunch and rachis, **g** bunch close-up, **h** male bud, **i** bract internal colour and flowers, **j** bract shape, **k** flower with colour of the anthers, **l** peduncle close-up, **m** hand, **n** fruits, **o** other photos (optional)

*Musa itinerans*



*Musa lutea* R.V.Valmayor, L.D.Danh & Häkkinen: Valmayor et al, Philipp. Agric. Sci. 87:110-118, 2004; Lý et al, Phytotaxa, 75(1):33-42, 2012; Mertens et al, Divers. Distrib., 27(4), 729-746, 2021.

**Type:** Viet Nam, Van Chan district, Yen Bai province, 18. IX.1994, *Le Dinh Danh* VNI-049 (holo-, PHH no. 003!).

**Description** Because the description of the type is very short, we propose a more extensive version.

Pseudostem 2–3 m in height, light green to green coloured below when leaf sheaths are removed (Fig. 6c). *Musa lutea* grows in small clusters. Petiole green, no waxiness, with moderate black–purple blotching at the base. Petiole canal margins erect (Fig. 6e), slightly winged, not clasping, with purple to blue and rim contrast with the petiole. Leaf blade upper face medium green to green with base oblique, asymmetrical (Fig. 6o). Cigar leaf green.

Peduncle hairless. bunch and male rachis erect, cone shape with stretched internodes at the female part. Flowers persist on the male rachis only on one to few hands near the bunch. Male bud is of medium shape, short, and low shouldered. The male bud bracts have an intermediate shape, are slightly imbricate, and the last lifted bract does not revolt before falling. Bract colour orange-red to red externally, orange-red colour internally (Fig. 6i, j). Compound tepal bright yellow with green lobes (Fig. 6i); anther yellow.

Bunch has 3–8 hands, each hand with 3–6 fruits. Fruit is 6–10 cm long, straight. Fruits green and in horizontal position when young, rich yellow and virtually hanging down at maturity (Fig. 6g, i, m, n). Fruit apex truncate with persistent flower relicts. Fruit pedicel length more than 20 mm and no visible sign of fusion. Fruit has very few seeds and display a pronounced parthenocarpy.

**Distribution:** A total of 6 *M. lutea* populations were found in the northwest in Yen Bai province and the northeast in Tuyen Quang and Cao Bang provinces (Fig. 1, Table 2). The elevation of populations was 85–483 m.

**Habitat:** *Musa lutea* often grows in small populations or as a single individual on cleared land, with a regeneration vegetation of low shrubs where there is no competition for light (e.g. along roadsides in the mountains or along large streams with few large trees).

Collection areas of *M. lutea* are situated in the north-western region (dry cold winters) below 700 m. Here, the first half of the year is cold and dry, whereas the second half is cold and humid (Lung et al. 2011).

**Conservation status:** *Musa lutea* is conserved as ex-situ collection at Plant Resources Center (Ha Noi, Viet Nam). A conservation assessment of the species by Mertens et al. (2021) showed that the species is Vulnerable.

Local names: *Musa lutea* is indigenous to Viet Nam with the local name Chuoi Rung Hoa Do meaning jungle banana with a red flower. Some other names were recorded as well (Table 2).

*Musa paracoccinea* A.Z.Liu & D.Z.Li: Liu et al, Bot. Bull. Acad. Sin., 43:77–81, 2002; Lý et al, Phytotaxa, 75(1):33–42, 2012; Mertens et al, Divers. Distrib., 27(4), 729–746, 2021.

**Type:** China, Yunnan, Jinping Hsien, in valley or along stream, 5.X.1998, A. Z. Liu 98007 (holo-, KUN; iso-, PE).

**Description:** The morphology of all the observed plants is completely conform to the description of the type by Liu et al. (2002) (Fig. 7).

Pseudostems are 4–6 m high, growing separately, 15–20 cm in diameter at the base, light green colour below when leaf sheaths are removed (Fig. 7c). Blotches at the petiole base are moderate, the petiole green without wax, petiole canal of third leaf margins erect (Fig. 7e); petiole margin not winged and clasped, green and rim contrast with the petiole. Leaves are dark green on the upper surface, base oblique (Fig. 7o). The cigar leaf is green.

Peduncle slightly hairy, bunch and male rachis erect, truncate; male rachis bare (Fig. 7f). Male bud has a fat shape, short length from 10 to 15 cm, low shoulder. The bract of the female flower has an obtuse shape, convolute imbrication, and the last lifted bract does not revolute; bracts are light pink-purple on both sides but internally lighter in colour (Fig. 7i, h and j). The compound tepal is bright yellow, lobe of compound tepal light green, anther has a cream colour (Fig. 7j).

Bunch has 5–10 hands, and each hand has 2–4 fruits. Fruits length 10–12 cm, slightly curved. Fruit apex point with persistent flower reflects (Fig. 7n). Fruit pedicel length 15–20 mm and no visible sign of fusion, seeds numerous and brown.

**Additional descriptors:** the pseudostem has a light green colour below when the outermost not-yet-dry leaf sheath is removed (Fig. 7c); leaf blade base oblique (Fig. 7o); male bud has a fat shape, low shoulder, and is 10–15 cm long (Fig. 7h); mature fruits curving upwards towards the axis.

**Distribution:** A total of 14 populations of *Musa paracoccinea* populations were found (Fig. 1, Table 2). The elevation of the collections of *M. paracoccinea* was 127–966 m.

**Habitat:** *Musa paracoccinea* was found along streams and roads, or on cleared land, always outside the shadow.

*Musa paracoccinea* was firstly reported in Yun-nan (China) (Liu et al. 2002). This Chinese province shares a border with Lao Cai and Ha Giang provinces in Viet Nam, where we found the six populations of *M. paracoccinea*.

*Musa paracoccinea* populations were found in the tropical monsoon climate region at an altitude above 600–700 m. In this area, the first half of the year is cold (< 18 °C, Supplementary Table 2) and dry whereas the second half is cold and humid. Additionally, *M. paracoccinea* was found in areas with dry, cold winters, and elevations over 700 m in the north-western Yen Bai, Lao Cai, Lai Chau, Dien Bien regions. The collected areas belonged to the north–north-western climate sub-region type (Supplementary Table 2) (Van 2015).

**Conservation status:** *Musa paracoccinea* is conserved as ex-situ collection at Plant Resources Center (Ha Noi, Viet Nam). A conservation assessment of the species by (Mertens et al. 2021) showed that the species is Least Concern or Near-Threatened.

**Local names:** In Viet Nam *Musa paracoccinea* is referred to as jungle banana having a red male bud. Local names in each ethnic group were recorded and added to Table 2.

*Musa haekkinenii* N.S.Lý & Haev.: Lý et al, Phytotaxa, 75(1):33–42, 2012.

**Type:** Vietnam. Phu Tho Province: Phu Tho District, Phu Ho Commune, 21°27'1" N, 105°15'16" E,

54 m, 19 November 2008, T. Haevermans et al. 508 (Holotype P! (incl. spirit material), isotypes VNM!, H!).

**Description:** The observed single specimen (Distribution and Habitat) corresponds completely with the type extensively described by (Sâm et al. 2012).

Pseudostem is about 1–1.5 m in height, slender, suckers freely, diameter at the base is very small size (3–7 cm), light green coloured below when leaf sheaths are removed. Blotches at the petiole base sparse, small, brown; petiole of the third leaf has margin erect (Fig. 8e), petiole margin not winged and clasp, brown, no wax, and rim contrasts with the petiole. The leaves are without wax and medium green to dark green on the upper surface, light green to medium green on the lower surface, base oblique (Fig. 8o). Cigar leaf medium green.

The peduncle is without hair; the bunch and male rachis erect, bunch has spaced stretches and cylindrical shape, on male rachis, bract does not fall. The male bud has a skinny shape, short length, and low shouldered (Fig. 8h). The bract of the male flower has an intermediate to obtuse shape, moderate imprecation, and the last lifted bract does not revolute, orange-red on both sides, persistent and obliquely upwards to axis (Fig. 8f, g). Compound tepal is orange and light green in lobes, anther cream (Fig. 8k).

Bunch about 3–6 hands, each hand with 2–4 fruits, fruit length from 3–4 cm, straight, fruit apex round with persistent flower relicts, pedicel length less than 10 mm and no visible sign fusion and without mature fruits and seeds.

To note that fertilized fruits were absent in all cases where the plants were observed, probably because growing only in gardens.

**Distribution:** This species is known only from cultivated material. Our sample was collected in a national park in Ba Vi district (115 m above sea level) (Ha Noi area) in 2017 (Fig. 1, Table 2). The two previous samples were first found in Phu Tho and Son La provinces in 2008 and 2010 (Sâm et al. 2012).

**Habitat:** The specimen was collected from Ba Vi National Park. Ba Vi district has a rainy season from April to October, with an average temperature of 23–28.6 °C. Precipitation is 1832.2 mm (equivalent to



90.87% of annual rainfall), average monthly rainfall is over 100 mm. The highest rainfall occurs in August (339.6 mm). Total days with rain days are 104 days; the dry season is from November to March, with an average temperature of 15.8–20 °C. The rainfall in these months is very low, from 15.0 to 64.4 mm (Ba Vi Web Portal 2020). The previous *Musa haekkinenii* samples were also collected by Lý Ngọc Sâm et al. (2012) in the tropical monsoon climate region showed in the Supplementary Table 2, at the same altitude as for our collection.

**Conservation status:** *M. haekkinenii* is cultivated in Phu Tho and Son La provinces. Recently, the species was introduced in the ex-situ collection of the Plant Resources Center, (Ha Noi, Viet Nam). According to the IUCN, the species is among the Red List criteria and categories Lý Ngọc Sâm et al. (2012).

**Local names:** *M. haekkinenii* is called chuối rừng hoa đỏ, in Kinh language-meaning jungle banana with a red male bud (Table 2).

Key to the *Musa* species applicable for northern Viet Nam.

N°	Morphological characters	
1	Bunch and male rachis are erect	2
	Bunch and male rachis are not erect	4
2	Pseudostem more than 3 m in height, fruit light green during all stages of maturity	<i>Musa paracoccinea</i>
	Pseudostem less than 3 m in height, fruit is yellow during all stages of maturity	3
3	On male rachis, almost bare; bracts falling down	<i>Musa lutea</i>
	On male rachis, bracts dense, covering the stalk, persistent, not falling down	<i>Musa haekkinenii</i>

N°	Morphological characters	
4	Bract does not revolute before falling	<i>Musa balbisiana</i>
	Bract revolutes before falling	5
5	Pseudostem about 3–7 m and up to 12 m in high, growing separately with long rhizomes far from mother plant; fruits length 7–12 cm, slightly curved, fruit apex pointed, fruit pedicel length 3–7 cm, partial fusion	<i>Musa itinerans</i>
	Pseudostem about 3 m, growing in cluster or clumps, sucker near mother plant; fruit length 5–10 cm, curved, fruit apex bottle-necked, fruit pedicel short length, 0.5–1 cm, no visible sign of fusion	<i>Musa acuminata</i>

## Discussion

In total 80 populations of following six *Musa* species were found and collected in northern Viet Nam: *M. acuminata*, *M. balbisiana*, and *M. itinerans*, of the section *Eumusa* and *M. lutea*, *M. paracoccinea* and *M. haekkinenii* of the section *Callimusa*. Since their populations occur in various forest ecological habitat types, those roughly reflect the degree of presence throughout both the north-eastern and north-western region (Table 2): *M. itinerans* (8), *M. acuminata* (6), *M. balbisiana* (5), *M. paracoccinea* (5), *M. lutea* (3), *M. haekkinenii* (1). Most of these species often display large populations and seem therefore to be adapted to a wide range of climate conditions, including different amounts of precipitation, and various temperature ranges. In general, *Musa* species

occur on very steep to flat slopes, from low to high elevations. Populations were more often found near streams where there was abundant water. In contrast, *M. lutea* and *M. paracoccinea* had small populations with limited topographical distributions.

**Fig. 5** Diversity in *Musa itinerans* Cheesman

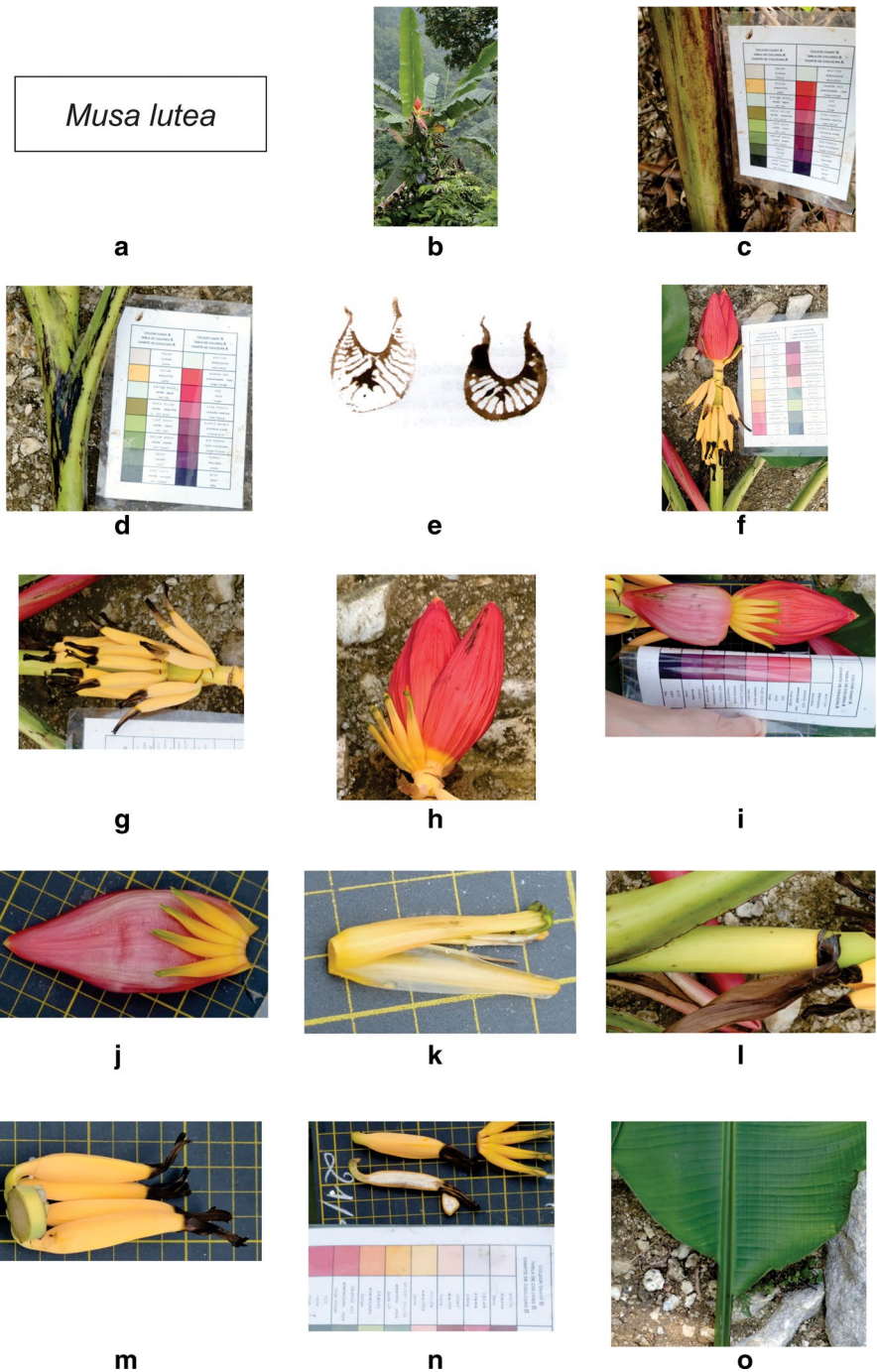


Color of fruit

Color of male bud

Color and diameter of pseudostem

**Fig. 6** *Musa lutea*  
R.V.Valmayor, L.D.Danh  
and Häkkinen: **a** label, **b**  
entire plant, **c** pseudostem  
underlayers, **d** neck, **e**  
petiole canal, **f** bunch and  
rachis, **g** bunch close-up,  
**h** male bud, **i** bract internal  
colour and flowers, **j** bract  
shape, **k** flower with colour  
of the anthers, **l** peduncle  
close-up, **m** hand, **n** fruits,  
**o** other photos (optional)

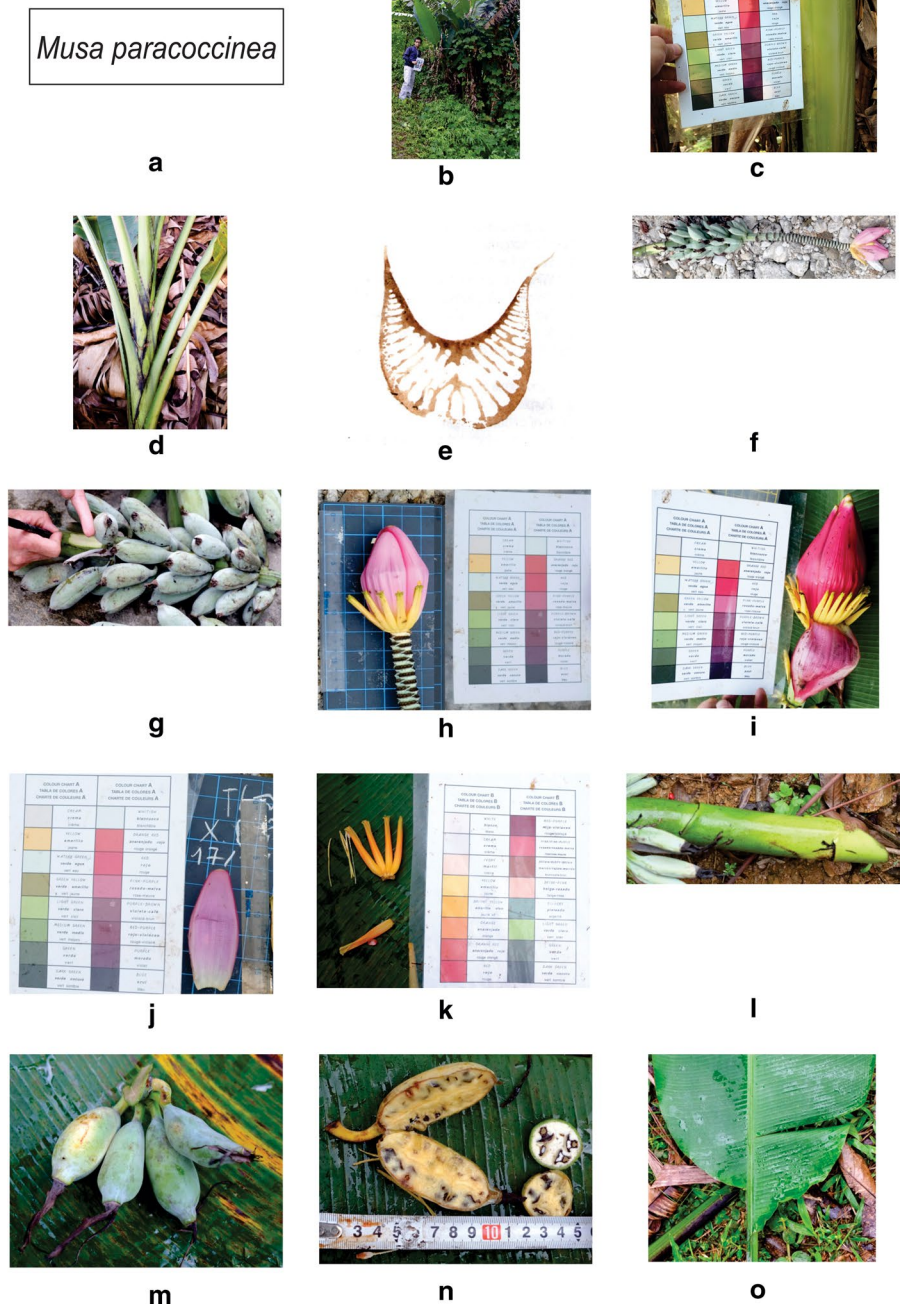


(Fig. 2c); the last lifted bracts on the male bud do not revolute (Fig. 2f); fruit pedicel length more than 21 mm i.e. slightly longer than the 1–2 cm by Cheesman (Cheesman 1948a, b). The *Musa acuminata* species had pseudostem cream coloured below when

leaf sheaths are removed (Fig. 3c); male bud has a skinny shape, a medium length between 20–30 cm, and a low shoulder (Fig. 3h and i); The *Musa itinerans* Cheesman displays a large variation per some descriptors in China (Häkkinen et al. 2008), and at



**Fig. 7** *Musa paracoccinea* A.Z.Liu and D.Z.Li: **a** label, **b** entire plant, **c** pseudostem underlayers, **d** neck, **e** petiole canal, **f** bunch and rachis, **g** bunch close-up, **h** male bud, **i** bract internal colour and flowers, **j** bract shape, **k** flower with colour of the anthers, **l** peduncle close-up, **m** hand, **n** fruits, **o** other photos (optional)

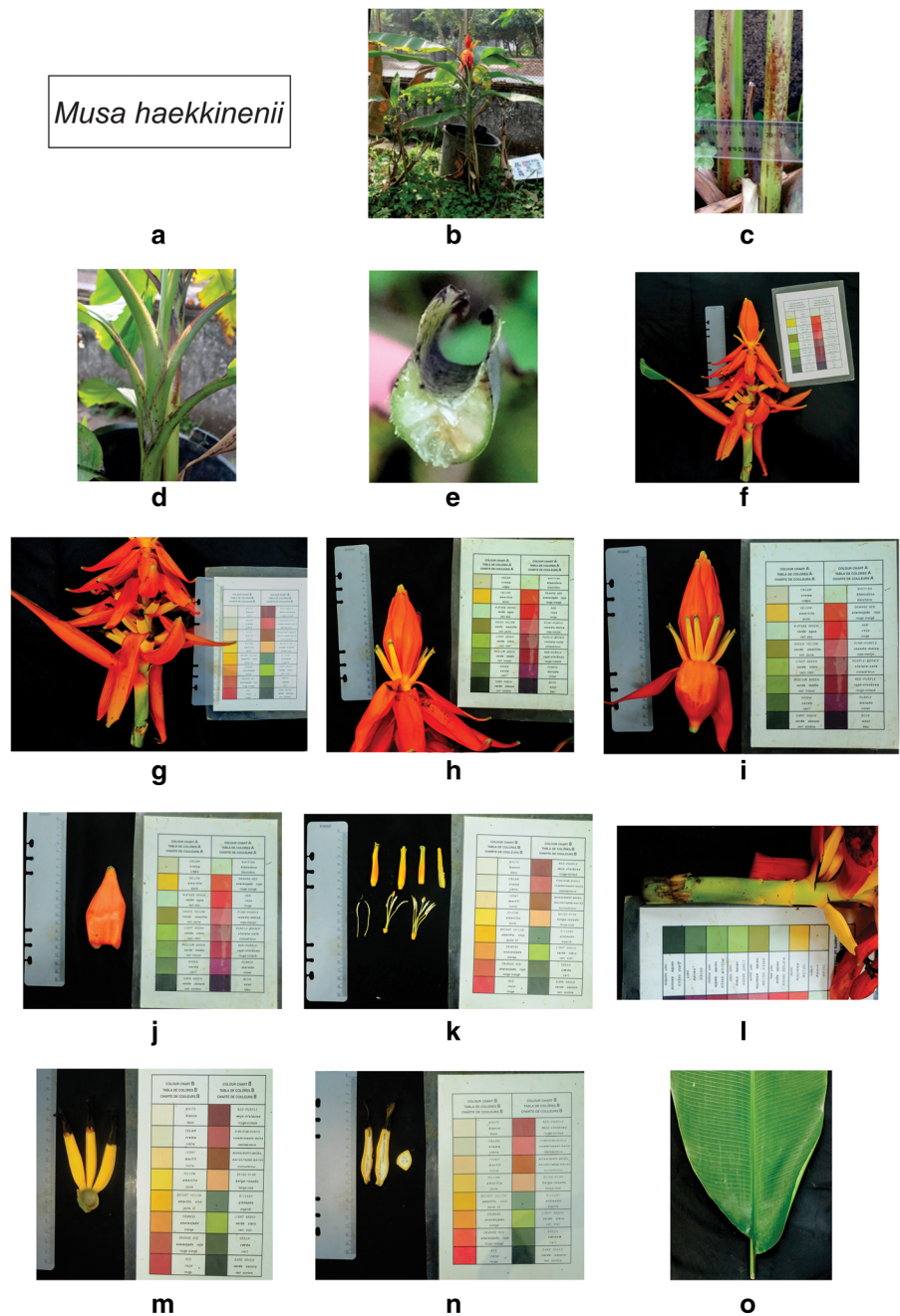


least one variant in Viet Nam has been classified as subspecies *annamica*. Several local variants have been found by our team in northern Viet Nam as is shown on Fig. 5. A due classification of the variants can now be carried out, whereby the descriptions by

Häkkinen et al. (2008) should be most helpful; the *M. paracoccinea* had the pseudostem has a light green colour below when the outermost not-yet-dry leaf sheath is removed (Fig. 7c); leaf blade base oblique (Fig. 7o); male bud has a fat shape, low shoulder,



**Fig. 8** *Musa haekkinenii* N.S.Lý and Haev.: **a** label, **b** entire plant, **c** pseudostem underlayers, **d** neck, **e** petiole canal, **f** bunch and rachis, **g** bunch close-up, **h** male bud, **i** bract internal colour and flowers, **j** bract shape, **k** flower with colour of the anthers, **l** peduncle close-up, **m** hand, **n** fruits, **o** other photos (optional)



and is 10–15 cm long (Fig. 7h); mature fruits curving upwards to axis. We observed a range of intraspecific morphological variation in *M. itinerans* with a considerable diversity in male flower colour (male bud varied from completely purple-brown to white–green with brown stripes), fruit colour (varying from light green to dark purple Fig. 5) and fruit size. Since a similar variation was observed in China (Häkkinen

et al. 2008), and because the species is present from northeastern India (in the west) to Taiwan (in the east), an international effort is needed in order to infer a correct intraspecific.

Quite surprising is the discovery of pronounced parthenocarpy in the *Callimusa* species *M. lutea* (Fig. 6n). Since the trend to parthenocarpy was also found in *M. balbisiana* (Table 2), the widespread

**Table 1** Description of wild banana species collected from norther Vietnam

	<i>Musa balbisiana</i> Colla	<i>Musa acuminata</i> Colla	<i>Musa itinerans</i> Cheesman	<i>Musa lutea</i> R.V.Valmayor, L.D.Danh and Hakkinen	<i>Musa paracoccinea</i> A.Z.Liu and D.Z.Li	<i>Musa haekkinenii</i> N.S. Lý and Haev
Pseudostem height (m)	6	3	3–7 (up to 12)	2–3	4–6	1–1.5
Colour of pseudostem	Green	Cream	Cream, yellow, purple–brown, red–purple	Green to light green	Light green	Light green
Blotches at the petiole base	No pigmentation	Moderate blotching	Moderate blotching	Moderate blotching	Moderate blotching	Sparse blotching
Blotches colour	Light green	Brown, black–purple	Purple–brown, black–purple	Black–purple	Green	Brown
Petiole canal of the third leaf	Margins curved inward	Margins spreading	Margins erect	Margins erect	Margins erect	Margins erect
Petiole margins winged	Not winged	Not winged	Not winged	Slightly winged	Not winged	Not winged
Petiole margins clasping	Clasping	Clasping	Clasping	Not clasping	Clasping	Clasping
Petiole margin colour	Green	Green	purple to blue	Purple to blue	Green	Brown
Edge of petiole margin	Contrast between margin and petiole	Contrast between margin and petiole	Contrast between margin and petiole	Contrast between margin and petiole	Contrast between margin and petiole	Contrast between margin and petiole
Pigmentation of outer surface of cigar leaf	Green	Green	Light red–purple	Green	Green	Medium green
Peduncle hairiness	Hairless	Highly–short hairy	Slightly hairy	Hairless	Slightly hairy	Hairless
Bunch position	Hanging vertically	At about 45°	At about 45°	Erect	Erect	Erect
Bunch shape	Cone	Cylindrical to truncate	Cylindrical	Cone	Truncate	Cylindrical
Male rachis position	Falling vertically	Hanging horizontally	At about 45 degree angle	Erect	Erect	Erect
Male rachis appearance	Male bracts above male bud	Bare	Bare	Neutral flowers on one to few hands only near the bunch	Bare	Male bracts persistent, obliquely upwards to axis
Male bud shape	Skinny	Skinny	Small to medium	Medium	Fat	Skinny
Male bud length	Medium	Medium	Medium	Short	Short	Short
Male bud shoulder	Low shouldered	Low shouldered	Low shouldered	Low shouldered	Low shouldered	Low shouldered
Bract apex shape	Obtuse	Intermediate	Obtuse	Intermediate	Obtuse	Intermediate to obtuse
Bract imbrication	Moderately imbricate	Moderately imbricate	Convolute	Slightly imbricate	Convolute	Moderately imbricate
Bract behaviour before falling	Not revolute	Revolute	Revolute	Not revolute	Not revolute	Not revolute
Colour of the bract external face	Red–purple	Purple	Red–purple	Orange–red to red	Pink–purple	Orange–red

Table 1 (continued)

	<i>Musa balbisiana</i> Colla	<i>Musa acuminata</i> Colla	<i>Musa itinerans</i> Cheesman	<i>Musa lutea</i> R.V.Valmayor, L.D.Danh and Hakkinen	<i>Musa paracoccinea</i> A.Z.Liu and D.Z.Li	<i>Musa haekkinenii</i> N.S. Ly and Haev
Colour of the bract internal face	Red	Purple	Yellow	Orange red	Light pink-purple	Orange-red
Compound tepal main colour	Pink-purple	Yellow	Yellow	Bright yellow	Light yellow	Orange
Lobe colour of compound tepal	Bright yellow	Bright yellow	Bright yellow	Green	Light green	Light green
Anther colour	Yellow	brown-rusty brown	Bright yellow	Yellow	Cream	Cream
Number of hands on the whole bunch	8–10	10–15	5–15	3–8	5–10	3–6
Number of fruits on the mid-hand of the bunch	8–20	10–30	10–20	3–6	2–4	2–4
Fruit length (cm)	5–10	5–10	7–12	6–10	10–12	3–4
Fruit shape	Obovoid and slightly curved	Curved	Slightly curved	Straight	Slightly curved	Straight
Fruit apex	Pointed	Bottle-necked	Pointed	Truncate	Pointed	Round
Remains of flower relicts at fruit apex	Persistent flower relicts	Without flower relicts	Without flower relicts	Persistent flower relicts	Persistent flower relicts	Persistent flower relicts
Fruit pedicel length (mm)	>21	5–10	30–70	>20	15–20	<10
Fusion of pedicels	No visible sign of fusion	No visible sign of fusion	Partially fused	No visible sign of fusion	No visible sign of fusion	No visible sign of fusion

**Table 2** Collected zone and traditional knowledge of wild bananas

Pop. No	Climate sub region/forest ecological habitat type	Herbarium number	Local name/ethnic group/meaning	Traditional uses of wild banana
<i>SECTION Eumusa</i>				
<i>Musa balbisiana</i> all in the Northwestern region				
1	B2.1/type 7	HNU 024664	"cuối peeng"/Tày/NG	Fruits used as medicine, pseudostem used as pig and buffalo fodder
2	B2.1/type 7		"chuối hột"/Kinh/banana has seed	Fruits used as medicine, pseudostem used as pig fodder leaves used as fish fodder
3	B2.1/type 7		"chuối hột"/Kinh/banana has seed	Fruits used as medicine, pseudostem used as pig fodder, leaves used as fish fodder
4	B2.1/type 5		"chiu pú"/Dao/jungle banana; "chi đòng"/Giáy/jungle banana. "trơ cò"/Mông/white banana;	The young pseudostem used as food, rhizomes used as medicine against stomachache
5	B2.1/type 5		"chiu pú"/Dao/jungle banana; "trơ cò"/Mông/white banana; "chi đòng"/Giáy/jungle banana	The young pseudostem used as food, rhizomes used as medicine against stomachache
6	B2.1/type 5		"chiu pú"/Dao/jungle banana; "trơ cò"/Mông/white banana; "chi đòng"/Giáy/jungle banana	The young pseudostem used as food, rhizomes used as medicine against stomachache
7	B2.1/type 5		"chuối hột"/Kinh/banana has seed	Fruits used as medicine
8	B2.1/type 5		"chuối hột"/Kinh/banana has seed	Fruits used as medicine
9	B1.1/type 1		"chuối hột"/Kinh/banana has seed	Fruits used as medicine
10	B1.1/type 1		"pề đón"/Kháng/jungle banana	Sold to China for traditional medicine
11	B1.1/type 4		"chuối rừng"/Kinh/jungle banana	Fruits used as medicine
12	B1.1/type 4		"chuối rừng"/Kinh/jungle banana	Fruits used as medicine
13	B1.1/type 1		"cuối cây nội"/Thái/jungle banana	Fruits used as medicine
14	B1.1/type 1		"chuối mốc"/Kinh/leaf has wax; "Moong"/Tày/NG	leaves used to wrap food in
Notes on disease/disease resistance: population No. 1 of <i>Musa balbisiana</i> species has found to be infected with banana bunchy top virus (BBTV)				
<i>Musa acuminata</i> Northeastern region				
15	B2.2/type 9	HNU 024665	"chuối mốc"/Kinh/leaf has wax; "Moong"/Tày/NG	Pseudostem used as pig and fish fodder
16	B2.3/type 9		"cuối cây"/Nùng/banana has small fruit	Fruits used as medicine, leaves used as fish fodder
17	B2.3/type 9		"cuối cây"/Nùng/banana has small fruit	Fruits used as medicine, leaves used as fish fodder
18	B2.3/type 9		"cuối cây"/Nùng/banana has small fruit	Fruits used as medicine
19	B2.2/type 9		"thiu chây"/Dao-long shirt	Fruits used as medicine
20	B2.3/type 14		"giuốc nằng"/Dao, Tày, Nùng/banana has small fruit	Fruits used as medicine
21	B2.3/type 14		"chuối rừng"/Kinh/jungle banana	Fruits used as medicine



**Table 2** (continued)

Pop. No	Climate sub region/forest ecological habitat type	Herbarium number	Local name/ethnic group/meaning	Traditional uses of wild banana
<i>Musa acuminata</i> Northwestern region				
22	B2.1/type 7	HNU 024665	"cuối peeng"/Tày/banana has small fruit	Fruits used as medicine
23	B2.1/type 7		"cuối peeng"/Tày/banana has small fruit	Fruits used as medicine
24	B2.3/type 7		"giuốc năng"/Dao, Tày, Nùng/banana has small fruit	Fruits used as medicine, leaves used as fish fodder
25	B2.1/type 5		"tfawp quav tfhws" (tróp qua trừ)/Mông/fruit look like shit of wild cat, etc., "chi đoòng"/Giáy/jungle banana, "chúu púu gáí"/Dao/fruit look like shit of animal	Fruits used as medicine against coughing (Mông), male bud used as food
26	B2.1/type 5		Same as No 25	Fruits used as medicine against coughing (Mông), male bud used as food
27	B2.1/type 5		Same as No 25	Fruits used as medicine against coughing (Mông), male bud used as food
28	B2.1/type 5		Same as No 25	Fruits used as medicine against coughing (Mông), male bud used as food. Fruits used as medicine
29	B1.2/type 2		"cọ vén"/Thái/jungle banana	Fruits used as medicine
30	B1.2/type 2		"cuối pá"/Thái/jungle banana	Fruits used as medicine
31	B1.1/type 1		"chuối hột nhỏ"/Kinh/small banana has seed	Fruits used as medicine
32	B1.1/type 1		"chuối hột"/Kinh/banana has seed	NG
33	B1.1/type 1		NG	Fruits used as medicine
Notes on disease/disease resistance: population no. 28 of <i>Musa acuminata</i> has found to be infected by BBTv				
<i>Musa itinerans</i> Northeastern region				
34	B2.2/type 9	HNU 024666	"chuối tím"/Kinh/banana has violet fruit	Male bud and young pseudostem used as food, fruits used as medicine
35	B2.2/type 9		"chuối tím"/Kinh/banana has violet fruit	Male bud and young pseudostem used as food, fruits used as medicine
36	B2.2/type 9		"chuối tím"/Kinh/banana has violet fruit	Male bud and young pseudostem used as food, fruits used as medicine
37	B2.3/type 9		"chuối tím"/Kinh/banana has violet	Male bud and young pseudostem used as food, fruits used as medicine
38	B2.3/type 9		"cuối suộc"/Nùng/banana has violet fruit	Male bud and young pseudostem used as food, fruits used as medicine, leaves used as fish fodder
39	B2.2/type 8		"chuối tím"/Kinh/banana has violet fruit	Male bud used as food, fruits used as medicine
40	B2.2/type 8		"chuối tím"/Kinh/banana has violet fruit	Male bud used as food, fruits used as medicine
41	B2.2/type 8		"chuối tím"/Kinh/banana has violet fruit	Male bud used as food, fruits used as medicine
42	B2.2/type 9		"thiu ui tung"/Dao-long shirt/banana has big fruit	Male bud used as food, fruits used as medicine
43	B2.3/type 14		"giuốc đòng"/Dao, Tày, Nùng/banana has big fruit	Fruits used as medicine, Male bud used as food

**Table 2** (continued)

Pop. No	Climate sub region/forest ecological habitat type	Herbarium number	Local name/ethnic group/meaning	Traditional uses of wild banana
<i>Musa itinerans</i> Northwestern region				
44	B2.1/type 7	HNU 024666	"cuối lộc"/Tây/banana has violet fruit	Male bud used as food, fruits used as medicine
45	B2.1/type 7		Same as No 44	Male bud used as food, fruits used as medicine
46	B2.1/type 7		Same as No 44	Male bud used as food, fruits used as medicine
47	B2.1/type 7		"chuối tím"/Kinh/banana has violet fruit	Fruits used as medicine, pseudostem used as pig fodder, male bud used as food
48	B2.1/type 7		Same as No 47	Fruits used as medicine, pseudostem used as pig fodder, male bud used as food
49	B2.1/type 7		Same as No 47	Fruits used as medicine, pseudostem used as pig fodder, male bud used as food
50	B2.1/type 7		"chuối tím"/Kinh/banana has violet fruit	Fruits used as medicine, Male bud used as food
51	B2.1/type 7		"chuối quả tím"/Kinh/banana has violet fruit	Male bud used as food, fruits used as medicine
52	B2.1/type 7		Same as No 51	Male bud used as food, fruits used as medicine
53	B2.1/type 5		"tfawp laib" (tróp lia)/Mông/banana has red fruit	Fruits used as medicine, Male bud used as food
54	B2.1/type 5		"chuối tím"/Kinh/banana has violet fruit	Fruits used as medicine, Male bud used as food
55	B1.2/type 2		NG/Thái/	NG
56	B1.2/type 2		"cuối pá"/Thái/jungle banana	Fruits used as medicine, pseudostem food for domestic animal (buffalo, cows, pig...)
57	B1.1/type 1		NG	NG
58	B1.1/type 1		NG	Fruits used as medicine
59	B1.1/type 1		"cuối tang"/Thái/jungle banana	Fruits used as medicine, pseudostem used as food for domestic animals
Notes on disease/disease resistance: Population No. 53 of <i>Musa itinerans</i> has found to be infected by BBTv (2 plants) and <i>Fusarium wilt</i> (3 plants)				
<b>SECTION Callimusa</b>				
<i>Musa lutea</i> Northeastern region				
60	B2.2/type 9	HNU 024670	"chuối đỏ"/Kinh/banana has red male bud; "cuối khê"/Tây/banana has red male bud	Flowers used for decoration
61	B2.3/type 14		"pi đeng"/Dao, Tây, Nùng/banana has red flower	Flowers used for decoration

**Table 2** (continued)

Pop. No	Climate sub region/forest ecological habitat type	Herbarium number	Local name/ethnic group/meaning	Traditional uses of wild banana
<i>Musa lutea</i> Northwestern region				
62	B2.1/type 7	HNU 024670	"cuối vẹc"/Tày/banana has red male bud	Flowers used for decoration
63	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red male bud	Flowers used for decoration
64	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red male bud	Flowers used for decoration
65	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red male bud	Flowers used for decoration
Notes on disease/disease resistance: Population 64 has found to be infected by <i>Fusarium wilt</i> (Race 1) (Le Thi et al. 2022)				
<i>Musa paracoccinea</i> Northeastern region				
66	B2.2/type 9	HNU 024667	"chuối khê"/Kinh/banana has red male bud	Flowers used for decoration on altars
67	B2.2/type 8		"chuối hoa đỏ"/Kinh/banana has red male bud	Flowers used for decoration
68	B2.2/type 8		"cuối vẹc"/Tày/banana has red male bud	Flowers used for decoration
69	B2.2/type 8		"mác vẹc"/Tày/banana has red flower	Flowers used for worshipping rituals (dead), mixture with bone or fish for soup; mature fruit soaked with alcohol for several months to treat liver disease, ripen fruit be eaten; young pseudostem be eaten after boiled or steamed
70	B2.2/type 9		"thiu đành"/Dao-long shirt/banana has red male bud	Male bud used for food and medicine
<i>Musa paracoccinea</i> Northwestern region				
71	B2.1/type 7	HNU 024667	"cuối vẹc"/Tày/banana has red male bud	Flowers used for decoration
72	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red male bud	Flowers used for decoration
73	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red flower	Flowers used for decoration
74	B2.1/type 7		"chuối hoa đỏ"/Kinh/banana has red flower	Flowers used for decoration
75	B2.1/type 7		"chuối đỏ"/Kinh/banana has red male bud	Flowers used for decoration
76	B1.1/type 1		"chuối hoa đỏ"/Kinh/banana has red flower	Fruits used as medicine
77	B1.1/type 1		NG	NG
78	B1.1/type 4		"chuối hoa đỏ" /Kinh/banana has red flower	Fruits used as medicine
79	B1.1/type 1		NG/Mãng/NG	Fruits used as medicine
<i>Musa haekkinenii</i> Red river delta				
80	Near B2.4/type 17	HNU 024669	"chuối đỏ"/Kinh/banana has red male bud	Flowers used for decoration

NG = Not given

opinion that parthenocarpy is restricted to *M. acuminata* (i.e. its edible diploids) can no longer be hold. Of crucial importance in (phylo) genetics is its presence in the widely different *Callimusa* section ( $n=10$ ), thus showing that at least the potential for parthenocarpy seems to exist already at the *Musa* genus level.

Interestingly, some disease symptoms were recorded in wild banana. *Musa balbisiana*, *M. acuminata* and *M. itinerans* species were found to be infected by Banana Bunchy Top Virus in the populations 1, 28 and 53, respectively. Population 53 was also infected by *Fusarium wilt*. The population 64, *Musa lutea*, was also infected by *F. wilt* (Race 1) (Le Thi et al. 2022).

**Author contributions** TVD, DTV and SBJ designed the study. TVD, SK, LTL, DTV, AM, and SBJ collected the data. TVD, DTV, SBJ performed the clarification. TVD and DTV drafted the manuscript and DTV, TDV, SK, SBJ, EDL and TTN thoroughly revised it. All authors have contributed to the manuscript and approve this final version.

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## Declarations

**Conflict of interest** Authors declare that non-conflict of interest related to the work for publication.

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