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Musa yunnanensis (Musaceae) and its intraspecific taxa in China

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Musa yunnanensis Häkkinen & H. Wang (Musaceae) is distributed across the Mekong River watershed in Yunnan, China. In the present study its intraspecific taxa are thoroughly investigated. These wild *Musa* species and varieties are commonly planted for animal fodder in higher elevations due to their cold tolerance. Three varieties of *M. yunnanensis* described here as a new taxa, *M. yunnanensis* var. *caii* Häkkinen & H. Wang, *M. yunnanensis* var. *yongpingensis* Häkkinen & H. Wang and *M. yunnanensis* var. *jingdongensis* Häkkinen & H. Wang, are morphologically described and illustrated based on data from field studies in Yunnan, China in 2005, 2006 and 2007. A table with the diagnostic characters of the new varieties, as well as for *M. yunnanensis* var. *yunnanensis*, is provided.

The genus *Musa* L. (Linnaeus 1753) belongs to the family Musaceae Juss. (Jussieu 1789), which includes two other genera, *Ensete* Horan. (Horaninow 1862) and *Musella* (Franch.) C. Y. Wu (Franchet 1889, Wu 1978). It has been estimated that *Musa* comprises about 70 species and numerous subspecies and varieties (Häkkinen and Väre 2008 freely accessible at: <http://www.mnhn.fr/museum/front/medias/publication/14895_a08n1a7.pdf>). However, many regions within the centre of diversification of the genus in southeast Asia have not been explored systematically and new species continue to be discovered. Studies of the varieties of *M. yunnanensis* in subtropical areas in Yunnan, China have shown that there are wild banana populations cultivated as animal fodder in the mountains above 1550 meters and below the elevation of 2250 meters. These can tolerate the freezing temperatures that occur here every winter without any damages (Häkkinen pers. obs.). However, it is obvious that these *M. yunnanensis* varieties have been introduced in rural areas by man from unknown origins in ancient times and have since escaped into the wild. Throughout the tropics, in prehistoric times man has dispersed almost all of the known *Musa* species that were of any use. The origins of most *Musa* species still remain unknown. The first author has studied herbaria and the literature on *Musa* (Häkkinen and Väre 2008) but has not found any herbarium specimens or any mentioning in the literature of these new varieties, neither of *M. yunnanensis* var. *yunnanensis*, before its description (Häkkinen and Wang 2007). The here described cultivated and wild populations are growing as isolated populations and are not sympatric with any other *Musa* species, with the exception that *M. yunnanensis* var. *yunnanensis* is growing sympatrically with *Musa itinerans* (Häkkinen and Wang 2007, Häkkinen et al. 2008). However, before our investigation nobody realized the distinctiveness of *M. yunnanensis* or its varieties, even though it is widely dispersed throughout the Mekong watershed in Yunnan. The taxon was not at all mentioned in the Chinese Musaceae literature (Li 1978, 1981, 1996, Wu 1978, 1979, 1997, Wu and Kress 2000, Liu and Li 2001, Liu et al. 2002). One notable characteristic common to all the newly described varieties of *M. yunnanensis* is that they have monoclinous hermaphroditic female flowers that self-pollinate before the bract opens. Consequently, no hybrids of these two taxa have been observed.

Material and methods

This paper is based on extensive field observations on *Musa* made by the authors during expeditions in 2005, 2006 and 2007 to the Yunnan Province in China. The new varieties of *M. yunnanensis* viz. var. *caii,* var. *yongpingensis* and var. *jingdongensis* are described based on living plants in the field by completing the INIBAP *Musa* descriptor list (IPGRI-INIBAP/CIRAD 1996). The descriptive terms herein agree with those of the traditional banana taxonomy (Simmonds 1962, 1966). Relevant portions of the plant specimens were deposited as holotypes at the herbarium of the Xishuangbanna Trop. Bot. Gard. (HITBC), with isotypes at the IBSC and PE.

Table 1. The main diagnostic characterers of the varieties of *Musa yunnanensis* Häkkinen & H. Wang.

	M. yunnanensis var. *yunnanensis*	*M. yunnanensis* var. *caii*	*M. yunnanensis* var. *yongpingensis*	*M. yunnanensis* var. *jingdongensis*
Figures		1a–d	2a–d	3a–d
Plant height	Up to 5 m	Up to 4 m	Up to 6 m	Up to 4 m
Number of suckers	Up to 6	Up to 15	Up to 25	Up to 15
Leaf habit	Intermediate	Intermediate	Erect	Intermediate
Underlying colour of the pseudo-stem	Light green	Light green	Green, pink at the base	Green
Pigmentation of the underlying pseudo-stem	Purple–black blotches	Devoid of pigmentations	Devoid of pigmentations	Devoid of pigmentations
Sap colour	Watery	Milky	Watery	Watery
Petiole margins	Curved inwards	Curved inwards with broad dry wings	Curved inwards with dry wings	Curved inwards
Leaf size (cm)	250 × 60	220 × 70	250 × 85	210 × 65
Colour of leaf upper surface	Green	Medium green	Medium green	Green
Colour of leaf lower surface	Medium green	Pale green	Light green	Light green
Colour of midrib dorsal surface	Light green	Pale green	Pale green	Pale yellow
Colour of midrib ventral surface	Light green	Pink–purple	Pale green	Pale yellow
Peduncle colour	Light green to black	Light green	Rusty brown	Brown
Peduncle hairiness	Very hairy with short hairs	Hairy with short hairs	Hairy with short hairs	Hairy with short hairs
Female bud shape	Lanceolate 40 × 9 cm	Intermediate 35 × 11.5 cm	Lanceolate 38 × 9 cm	Intermediate 40 × 10 cm
Female bract lifting	Lifting several bracts at a time	Lifting one bract at a time	Lifting one or two bracts at a time	Lifting one bract at a time
Colour of the bract external face	Red–purple	Blue–purple	Blue–purple	Red–purple
Colour of the bract internal face	Cream	Cream to pink	Cream	Cream
Male bud shape	Lanceolate 12 × 4 cm	Intermediate 18 × 9 cm	Intermediate 20 × 10 cm	Lanceolate 10 × 3.5 cm
Colour of the bract external face	Red–purple	Blue–purple	Blue–purple	Red–purple
Male bract lifting	Lifting several bracts at a time, revolute	Lifting one bract at a time, not revolute	Lifting one or two bracts at a time, revolute	Lifting one bract at a time, not revolute
Male bud aborting	Aborting before the fruits mature	Persistent	Aborting before the fruits mature	Persistent
Number of fruits	8 hands, 15 fruits per hand in 2 rows	3 hands, 8 fruits per hand in 2 rows	10 hands, 8 fruits per hand in 2 rows	10 hands, 12 fruits per hand in 2 rows
Fruit shape	8 cm long, slightly curved and ridged	10 cm long, straight and pronounced ridged	14 cm long, straight and pronounced ridged	10 cm long, curved and slightly ridged
Immature fruit peel colour	Green	Light green	Green	Light green
Fruit peel colour at maturity	Light green, splitting lengthwise at maturity	Pale yellow–green with small black blotches	Pale yellow with large black blotches	Yellow
Number of seeds per fruit	80–100	60–65	80–85	90–100

Musa yunnanensis Häkkinen & H. Wang

Type: China. Yunnan Province, Xishuangbanna District, Jinghong County, Longpa, 1150 m a.s.l., 13 Nov 2005, Wang Hong 8303 (holotype: HITBC: 111442!, 114501! 114580!, 114581!, 114582! [5 sheets]; isotypes: H!, IBSC!, MO!, PE!, QBG!).

Musa yunnanensis var. *yunnanensis* (Table 1)

The variety *M. yunnanensis* var. *yunnanensis* grows abundantly in the Mekong river watersheds from the tropical zone to the subtropical zone on slopes from 500 to 1800 meters above sea level. The plants can tolerate seasonal frosts, which may occur in January and February especially at higher elevations in subtropical areas in Yunnan. The seeds, which are dispersed by monkeys and bats, germinate easily even in shaded environments. However, these young plants can remain dormant for years. When exposed to full light, the young plants begin to grow quickly. This species is called the tree banana by the local people because it can grow among the tree branches under the forest canopy, with some plants 1 to 2 meters high. The plants stay dormant under the closed canopy, but as the canopy opens, they rapidly develop (Häkkinen pers. obs.).

Musa yunnanensis var. *caii* Häkkinen & H. Wang var. nov. (Fig. 1a, Table 1)

Planta normalis, surculos 10–15 (in aliquot locis usque ad 25) parente 5–10 cm distantes libere producens, positione verticali. Truncus maturitate usque ad 4 m longus, dilute viridis, ceram et pigmentationes carens; succus lactarius. Petiolus usque ad 50 cm longus. Folii habitus intermedius; lamina usque ad 220 × 70 cm, anguste elliptica, apice truncata, basi symmetrica hinc atque illinc rotundata

Figure 1. (a) holotype specimen of *M. yunnanensis* var. *caii* (HITBC: 125195). Courtesy of XTBG. Photo: He Liqing, XTBG, (b) inflorescence and male bud of *M. yunnanensis* var. *caii*. Photo: Wang Hong, XTBG, (c) male bud and flowers of *M. yunnanensis* var. *caii*. Photo: Wang Hong, XTBG, (d) unripe seeds of *M. yunnanensis* var. *caii*. Photo: Wang Hong, XTBG.

auriculataque. Inflorescentia primo horizontalis deinde pendula; pedunculus usque ad 30–50 cm longus et 5.5 cm in diametro, pallide viridis, pilis brevibus sparse vestitus. Alabastrum femineum lanceolatum, usque ad 35 × 11.5 cm; bracteae externe caerulescenti–purpureae, interne cremeae, sine imbricationibus, ceraceusculae, quarum una insimul aperta, non revolutae ante cadentem. Flores basales hermaphroditi. Alabastrum masculinum intermedium, bractea una insimul aperta, non revoluta ante cadentem, non aboriens ante maturitatem fructuum. Flores masculini fere 15 in quaque bractea, in seriebus duabus. Racemus fructuum compactus, fasciculis 3 et fructibus 8 in quoque fasciculo, in seriebus duabus, fructibus sub angulo recto ad axem disopsitis; quoque fructu usque ad 10 cm longo, 5.5 cm in diametro; fructus immaturus valde costatus et pallide viridis, maturitate parum costatus et flavo-virescens maculis parvis atris. Semina 60–65 in quoque fructu.

Type: China. Yunnan Province, Simao District, Jinggu County, Yongping, Bianjiang, by a ditch on a mountainside, 1850 m a.s.l., 10 Aug 2006, Wang Hong 8259 (holotype: HITBC: 125195!, 125201!, 125207! [3 Sheets], isotypes: IBSC!, PE!).

Plant normal, freely suckering, close to parent plant 5–10 cm, with up to 10–15 suckers (in some habitat up to 25), position vertical (Fig. 1b). Mature pseudo-stem to 4 m high, covered with old brown leaf sheaths, underlying colour light-green, devoid of wax and pigmentation; sap milky. Petiole to 50 cm long, light green, canal margins curved inwards with broad dry wings; bases winged and clasping the pseudo-stem with black sparse blotching. Leaf habit intermediate, with very corrugated lamina; lamina to 220 × 70 cm, narrowly elliptic, truncate at the apex, upper surface green, lower surface pale green, appearance dull,

with some wax on surfaces; midrib dorsally pale green and ventrally pink–purple; leaf bases symmetric with both sides rounded and auriculate. Inflorescence at first horizontal and then falling vertically downward; peduncle to 30–50 cm long and 5.5 cm in diameter, light green and slightly clothed with short hairs; sterile bracts three, deciduous at the opening of the first female flowers. Female bud intermediate, to 35 × 11.5 cm; bracts blue–purple on the external and cream to pink on the internal faces, without imbrications, moderately waxy, one bract being open at the same time, not revolute before falling. Basal flowers hermaphrodite, with 3–5 bracts in two rows; ovary to 5.8 cm long, light green, with ovules arranged in two rows per locule; compound tepal to 4.8 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 2.0 cm long, translucent, rounded, with thickened keel and orange tip; stamens 5, purple with fertile pollen; style cream to brown with red spots, stigma brown–gray. Male bud intermediate, up to 18 × 9 cm, bracts blue–purple on the external and cream to pink on the internal faces, without imbrications, moderately waxy, one bract being open at the same time, not revolute before falling and not aborting the bud before the fruits mature (Fig. 1c). Male flowers on average 15 per bract in two rows; usually falling with the bract, compound tepal to 4.5 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 1.8 cm long, translucent, rounded, with thickened keel and orange tip; stamens 5, anthers purple with fertile pollen, anthers and style exserted. Fruit bunch compact, with 3 hands and 8 fruits per hand on average, in 2 rows, fingers perpendicular to the stalk; individual fruit to 10 cm long, 5.5 cm in diameter, immature fruit with pronounced ridges, mature fruit slightly ridged with up to 1 cm long pedicel, fruit apex rounded at maturity, without floral remnants, immature peel colour light–green, becoming pale yellow–green at maturity with small black blotches. Seeds black, tuberculate, irregularly angulate–depressed, to 8–9 mm across, 5–6 mm high, 60–65 per fruit (Fig. 1d).

Distribution and habitat

Musa yunnanensis var. *caii* occurs in very few isolated wild populations in Yunnan, China's subtropical regions at elevations from 1550 to 1850 meters above sea level, along roadsides, ravines and on steep slopes. However, it is also commonly cultivated for animal fodder in isolated rural areas in western Yunnan. It can withstand seasonal frost and snow, which it faces each winter in its range. We can assume that those wild populations were introduced from the seeds of cultivated ones dispersed by birds and bats. The origin of the cultivated populations is still unknown. We observed over 10 wild populations of *M. yunnanensis* var. *caii* and over 50 cultivated populations during our field studies in a small western area of the Yunnan Province, with the individual populations varying from just a few plants up to tens. *Musa yunnanensis* var. *caii* is commonly cultivated for fodder by farmers up to 1850 meters elevation by collecting suckers from those wild populations. It is notable that in those mountainous areas no other *Musa* species are cultivated so the populations of *M. yunnanensis* var. *caii* are completely isolated.

Additional specimens examined (paratypes)

China. Yunnan Province, Xishuangbanna District, Jinghong County, Damenglong, on Mt Mengsong, alt. 1850 m a.s.l., 29 Nov 2005, Wang Hong 8363 (HITBC: 112225!, 112226!, 112227!, 112228!, 112242!, 111439!); Simao District, Jinggu County, Yongping, Bianjiang, by a ditch on a mountainside, 1850 m a.s.l., 10 Aug 2006, Wang Hong 8258, 8260 (HITBC: 125213!, 125204!); eastern side of the highway from Simao to Puer, about 11 km to Simao City, 8 Nov 2007, M. Häkkinen 635 (HITBC: 125127!).

Musa yunnanensis var. *yongpingensis* Häkkinen & H. Wang var. nov. (Fig. 2a, Table 1)

Planta robusta, surculos 15–25 parente 0–10 cm distantes libere producens, positione verticali. Truncus maturitate usque ad 6 m longus, viridis, basi roseus, ceram et pigmentationes carens; succus aquosus. Petiolus usque ad 80 cm longus. Folii habitus erectus; lamina usque ad 250 × 85 cm, anguste elliptica apice truncata, basi asymmetrica hinc atque illinc rotundata auriculataque. Inflorescentia primo fere horizontalis leviter arcuata deinde pendula; pedunculus usque ad 40 cm longus et 6 cm in diametro, viridis usque ferrugineus, pilis brevibus vestitus. Alabastrum femineum lanceolatum, usque ad 38 × 9 cm; bracteae externe caerulescenti–purpureae, interne cremeae, sine imbricationibus, ceraceae, quarum 1–2 insimul apertae, revolutae ante cadentem. Flores basales hermaphroditi. Alabastrum masculinum intermedium, bracteae 1–2 insimul apertae, revolutae ante cadentem, aborientes ante maturitatem fructuum. Flores masculini fere 15 in quaque bractea, in seriebus duabus. Racemus fructuum compactus, fasciculis 9–10 et fructibus 5–8 in quoque fasciculo, in seriebus duabus, fructibus sub angulo recto recto ad axem dispositis; quoque fructu usque ad 14 cm longo, 5 cm in diametro, maturitate valde costato; fructus immaturus viridis, maturitate pallide flavescens maculis magnis atris. Semina 80–85 in quoque fructu.

Type: China. Yunnan Province, Simao District, Jinggu County, Yongping Town, on the highway from Jinggu City to Yongping, alt. 1829 m a.s.l., 23°26.691′N, 100°13.529′E, 5 Nov 2007, M. Häkkinen 632 (holotype: HITBC: 125426!, 125395! [2 sheets], isotypes: IBSC!, PE!).

Plant robust, densely suckering, close to parent plant 0–10 cm, with up to 15–25 suckers, position vertical (Fig. 2b). Mature pseudo-stem to 6 m high, covered partly with old brown leaf sheaths, underlying colour green, pink at the base, devoid of wax and pigmentations; sap watery. Petiole to 80 cm long, light green, waxy, canal margins curved inwards with dry papery wings; bases winged and clasping the pseudo-stem with black sparse blotching, very waxy. Leaf habit erect, with very corrugated lamina; lamina to 250 × 85 cm, narrowly elliptic, truncate at the

Figure 2. (a) holotype specimen of *M. yunnanensis* var. *yongpingensis* (HITBC: 125426). Courtesy of XTBG. Photo: He Liqing, XTBG, (b) inflorescence and male bud of *M. yunnanensis* var. *yongpingensis*. Photo: M. Häkkinen, (c) immature fruit bunch *M. yunnanensis* var. *yongpingensis*. Photo: M. Häkkinen, (d) mature seeds of *M. yunnanensis* var. *yongpingensis*. Photo: Wang Hong, XTBG.

apex, upper surface green, lower surface medium green, appearance dull, with wax on both surfaces; midrib dorsally and ventrally pale green; leaf bases asymmetric with both sides rounded and auriculate. Inflorescence at first nearly horizontal with a curve and then falling vertically downward; peduncle to 40 cm long and 6 cm in diameter, green to rusty-brown and clothed with short hairs; sterile bracts two, deciduous at the opening of the first female flowers. Female bud lanceolate, to 38 × 9 cm; bracts blue–purple on the external and cream on the internal faces, without imbrications, waxy, one or two bracts being open at the same time, revolute before falling. Basal flowers hermaphrodite; ovary to 5.6 cm long, light green, with ovules arranged in two rows per locule; compound tepal to 4.5 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 2.2 cm long, translucent, oval, with thickened keel and orange tip; stamens 5, purple with fertile pollen; style cream with red spots, stigma cream. Male bud intermediate, up to 20 × 10 cm, bracts blue–purple on the external and cream on the internal faces, without imbrications, moderately waxy, one or two bracts being open at the same time, revolute before falling, the whole bud aborting before the fruits mature. Male flowers on average 15 per bract in two rows, usually falling with the bract; compound tepal to 4.5 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 2.8 cm long, translucent, oval, with thickened keel and orange tip; stamens 5, anthers purple with fertile pollen, anthers and style exserted. Fruit bunch compact, with 9–10 hands and 5–8 fruits per hand on average, in 2 rows, fingers perpendicular to the stalk; individual fruit to 14 cm long, 5 cm in diameter, with pronounced ridges at maturity, with pedicel to 1 cm long, fruit apex pointed, without floral remnants, immature peel green, becoming pale yellow at maturity with large black blotches (Fig. 2c). Seeds black, tuberculate, irregularly angulate–depressed, to 8–9 mm across, 5–6 mm high, 80–85 per fruit (Fig. 2d).

Distribution and habitat

Musa yunnanensis var. *yongpingensis* occurs in the western part of the Yunnan Province in subtropical regions close to the Burma border at elevations from 1550 to 2250 meters above sea level, along roadsides, ravines and on steep slopes. It is more commonly cultivated than *M. yunnanensis* var.

caii in mountainous rural areas of western Yunnan. It can withstand seasonal frost and snow, which it faces in each winter from December to January in its range. We can assume that these populations emanates from plants that were introduced from Burma as we have been told that it grows in the wild there. We observed over 50 cultivated populations of *M. yunnanensis* var. *yongpingensis* but not a single wild population during our field studies in the areas close to the Burma border. The variety *M. yunnanensis* var. *yongpingensis* is commonly cultivated as fodder by farmers up to 2250 meters elevation. It is notable that in those mountainous areas there are no other *Musa* species growing with *M. yunnanensis* var. *yongpingensis*, so the populations are totally isolated.

Additional specimens examined (paratypes)

China. Yunnan Province, Lincang District, Shuangjiang County, Douge, on the highway side from Yongping to Shuangjiang City, 23°33.599′N, 100°23.545′E, 6 Nov 2007, M. Häkkinen 633 (HITBC: 125403!, 124576!, 125397!); 23°35.867′N, 100°06.630′E, 6 Nov 2007, M. Häkkinen 634 (HITBC: 125427!, 125396!, 125402!); Simao District, Jinggu County, on the highway side from Simao to Yongping, 23°29.414′N, 100°30.270′E, 16 Nov 2007, M. Häkkinen 637 (HITBC: 125117!); Lincang District, Douge, Cangyuan County, On the highway from Yongping to Douge, 23°36.145′N, 100°05.582′E, 17 Nov 2007, M. Häkkinen 638 (HITBC: 125113!); on the highway from Cangyuan to Gengma, 23°19.600′N, 099°19.741′E, 17 Nov 2007, M. Häkkinen 639, 23°07.416′N, 099°11.654′E, 17 Nov 2007, M. Häkkinen 640, 23°22.105′N, 098°58.782′E, 17 Nov 2007, M. Häkkinen 641 (HITBC: 125145!, 125111!, 125126!), Jingdong County, Mt. Wuliang Shan, on the highway from Gengma to Jingdong, 24°41.607′N, 100°30.167′E, 19 Nov 2007, M. Häkkinen 644 (HITBC: 125135!).

Musa yunnanensis var. *jingdongensis* Häkkinen & H. Wang var. nov. (Fig. 3a, Table 1)

Planta normalis, surculos 10–15 parente 0–30 cm distantes libere producens, positione verticali. Truncus maturitate usque ad 4 m longus, viridis, ceram et pigmentationes carens; succus aquosus. Petiolus usque ad 50 cm longus. Folii habitus imtermedius; lamina usque ad 210 × 65 cm, anguste elliptica apice truncata, basi asymmetrica hinc atque illinc rotundata auriculataque. Inflorescentia primo fere horizontalis leviter arcuata deinde pendula; pedunculus usque ad 50 cm longus et 5 cm in diametro, brunneus, pilis brevibus sparse vestitus. Alabastrum femineum lanceolatum, usque ad 40 × 10 cm; bracteae externe rubro–purpureae, interne cremeae, sine imbricationibus, moderate ceraceae, quarum una insimul aperta, non revolutae ante cadentem. Flores basales hermaphroditi. Alabastrum masculinum lanceolatum, bractea una insimul aperta, non revoluta ante cadentem, non aboriens ante maturitatem fructuum. Flores masculini fere 16 in quaque bractea, in seriebus duabus. Racemus fructuum compactus, fasciculis 10 et fructibus fere 12 in quoque fasciculo, in seriebus duabus, fructibus antrorse arcuatis; quoque fructu usque ad 10 cm longo, 4.5 cm in diametro, maturitate leviter costato; fructus immaturus pallide viridis, maturitate flavescens. Semina 90–100 in quoque fructu.

Type: China. Yunnan Province, Simao District, Jingdong County, Mt Wuliang Shan Hengduan, on the highway from Gengma to Jingdong, 1613 m a.s.l., 24°40.729'N, 100°28.783'E, 19 Nov 2007, M. Häkkinen 642 (holotype: HITBC; 125121!, 125422!, 125428!, 126668! [4 sheets], isotypes: IBSC!, PE!).

Plant normal, freely suckering, close to parent plant 0–30 cm, with up to 10–15 suckers, position vertical. Mature pseudo-stem up to 4 m high, partly covered with old brown leaf sheaths, underlying colour green, devoid of wax and pigmentations; sap watery. Petiole to 50 cm long, green, very waxy, canal margins curved inwards; bases winged and clasping the pseudo-stem with black blotches, very waxy. Leaf habit intermediate, with very corrugated lamina; lamina to 210 × 65 cm, narrowly elliptic, truncate at the apex, upper surface green, lower surface medium green, appearance dull, with wax on both surfaces; midrib dorsally and ventrally pale yellow; leaf bases asymmetric with both sides rounded and auriculate (Fig. 3b). Inflorescence at first nearly horizontal with a curve, becoming horizontal and then falling vertically downward; peduncle to 50 cm long and 5 cm in diameter, brown and slightly clothed with short hairs; sterile bracts two, deciduous at the opening of the first female flowers. Female bud lanceolate, to 40 × 10 cm; bracts red–purple on external and cream on the internal faces, without imbrications, moderately waxy, one bract being open at the same time, not revolute before falling. Basal flowers hermaphrodite; ovary to 5.5 cm long, light green, with ovules arranged in two rows per locule; compound tepal to 4.3 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 2.3 cm long, translucent, boat shape with thickened keel and yellow tip; stamens 5, purple with fertile pollen; style cream with red spots, stigma brown–gray (Fig. 3c). Male bud lanceolate, up to 10 × 3.5 cm, bracts red–purple on the external and cream on the internal faces, without imbrications, moderately waxy, one bract being open at the same time, not revolute before falling and not aborting the bud before the fruits mature (Fig. 3d). Male flowers on average 16 per bract in two rows usually falling with the bract; compound tepal to 3.5 cm long with two prominent thickened keels and hyaline margins, cream to yellow with 5-toothed orange apex; free tepal to 1.6 cm long, translucent, boat shape with thickened keel and yellow tip; stamens 5, anthers purple with fertile pollen, anthers and style exserted. Fruit bunch compact, with 10 hands and 12 fruits per hand on average, in 2 rows, fingers curved upwards; individual fruit to 10 cm long, 4.5 cm in diameter, mature fruit with slightly pronounced ridges, with pedicel to 2 cm long, fruit apex rounded, without

Figure 3. (a) holotype specimen of *M. yunnanensis* var. *jindongensis* (HITBC: 126668). Courtesy of XTBG. Photo: He Liqing, XTBG, (b) inflorescence and male bud of *M. yunnanensis* var. *jindongensis.* Photo: M. Häkkinen, (c) female flowers of *M. yunnanensis* var. *jindongensis.* Photo: M. Häkkinen, (d) pseuso-stems of *M. yunnanensis* var. *jindongensis.* Photo: M. Häkkinen.

floral remnants, immature peel light-green, becoming yellow at maturity. Seeds black, tuberculate, irregularly angulate–depressed, to 4–5 mm across, 3–4 mm high, 90–100 per fruit.

Distribution and habitat

We found *M. yunnanensis* var. *jingdongensis* only in one cultivated population at Mt Wuliang Shan Hengduan, at an elevation of some 1600 meters above sea level with only some 10 individual plants. It was cultivated for animal fodder together with *M. yunnanensis* var. *yongpingensis.*

Additional specimens examined (paratypes)

China. Yunnan Province, Simao District, Jingdong County, Mt Wuliang Shan, on the highway from Gengma to Jingdong, 24°41.192′N, 100°29.027′E, 19 Nov 2007, M. Häkkinen 643 (HITBC: 125138!).

Etymology

The new variety of *Musa yunnanensis* var. *caii* is named in honour of eminent botanist Prof. Cai Xitao, the first director of the Xishuangbanna Trop. Bot. Gard., for his

great contributions to the botany in China and to the XTBG garden. The two other varieties *M. yunnanensis* var. *yongpingensis* and *M. yunnanensis* var. *jindongensis* are named in accordance with the names of the places where they were observed.

Conclusions

Four distinct varieties of *M. yunnanensis* have been revealed and are here formally described. It became evident during this study that *M. yunnanensis* is native to Yunnan, China and occurs across the Mekong River watershed. The newly described *M. yunnanensis* varieties may be of huge potential breeding value. They are so cold tolerant that they can stand several degrees of frost without any damage. They also appear to be disease resistant, as no common banana diseases have been observed among any of the visited wild or cultivated populations. However, it remains to be studied how well the new varieties would thrive in habitats below 1550 meters above sea level. *M. yunnanensis* var. *yunnanensis* is thriving well at elevations from 500 to 1800 metres above sea level. It is also notable that all these described varieties have basal, hermaphroditic female flowers and therefore self-pollination occurs before the floral bracts open.

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References

Franchet, A. R. 1889. Un nouveau type de *Musa*, *Musa lasiocarpa*. – J. Bot. (Morot) 3: 329.

Horaninow, P. F. 1862. Prodromus Monographiae Scitaminarum. Petropoli. – Academiae Caesareae Scientiarum.

Häkkinen, M. and Wang, H. 2007. New species and variety of *Musa* (Musaceae) from Yunnan, China. – Novon 17: 440–446.

Häkkinen, M. and Väre, H. 2008. Typification and check-list of *Musa* names (Musaceae) with nomenclatural notes. – Adansonia 30: 63–112.

Häkkinen, M. et al. 2008. *Musa itinerans* (Musaceae) and its intraspecific taxa in China. – Novon 18: 50–60.

IPGRI–INIBAP/CIRAD 1996. Description for bananas (*Musa* spp.). Int. network for the improvement of banana and plantain, Montpellier, France/Centre de cooperation int. en recherche agro. pour le dével., Montpellier, France. – Int. Plant Gen. Resour. Inst., Rome, Italy.

Jussieu, A. L. de. 1789. Ordo I, Musae, Ordo II, Cannae. – In: Genera plantarum. Paris, pp. 61–64.

Li, H. W. 1978. The Musaceae of Yunnan. – Acta Phytotax. Sin. 16: 54–64.

Li, H. W. 1981. Musaceae. – In: Wu, C. Y. (ed.), Flora Reipubl. Pop. Sin. Sci. Press. Vol. 16, pp. 2–14.

Li, Y. 1996. List of plants in Xishuangbanna. Musaceae. Edited by Xishuangbanna Trop. Bot. Gard., Dept of Ethnobotany, Kumning Inst. of Bot., Chinese Acad. of Sci., pp. 497–498.

Linnaeus, C. 1753. Species plantarum. – Laurentii Salvii, Stockholmiae.

Liu, A. Z. and Li, D. Z. 2001. The identity of *Musa wilsonii* in Chinese botanical literature. – Acta Bot. Yunnan. 23: 175–176.

Liu, A. Z. et al. 2002. Taxonomic notes on wild bananas (*Musa*) from China. – Bot. Bull. Acad. Sin. 43: 77–81.

Simmonds, N. W. 1962. The evolution of bananas. – Longmans.

Simmonds, N. W. 1966. Bananas. (2nd ed.). – Longmans.

Wu, C. Y. 1978. *Musella lasiocarpa.* – Acta Phytotax. Sin. 16: 56–57.

Wu, C. Y. 1979. Musaceae. – In: Yunnan Sheng Zhiwu Yanjiusuo (ed.), Flora Yunnanica 2. Kexue Chuban She, Beijing, pp. 725–733.

Wu, T. L. 1997. Notes on the Lowiaceae, Musaceae, and Zingiberaceae for the flora of China. – Novon 7: 440–442.

Wu, T. L. and Kress, W. J. 2000. Musaceae: – In: Wu, Z. Y. and Raven, P. H. (eds), Flora of China 24. Science Press, Miss. Bot. Gard. Press, pp. 314–318.