

## Reappraisal of sectional taxonomy in *Musa* (*Musaceae*)

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**Abstract** The present work is part of a continuing study on *Musa* taxa by the author. Several molecular analyses support acceptance of only two *Musa* sections, *M. sect. Musa* and *M. sect. Callimusa*. *Musa sect. Rhodochlamys* is synonymized with *M. sect. Musa* and *M. sect. Australimusa* and *M. sect. Ingentimusa* are treated as synonyms of *M. sect. Callimusa*. Species lists are provided for the two accepted sections.

**Keywords** *Musa*; *Musa sect. Australimusa*; *Musa sect. Callimusa*; *Musa sect. Rhodochlamys*; reappraisal; Southeast Asia

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### ■ INTRODUCTION

Linnaeus, in *Species Plantarum* (1753), was the first to assign scientific nomenclature to bananas by describing *Musa paradisiaca* (based on *Musa cliffortiana*—Linnaeus, 1736, 2007) while at the same time establishing the modern botanical nomenclature, which is still in wide use today. Numerous additional species of (wild) bananas have been described since, which botanists have categorized into sections or subgenera based on morphology. The edible bananas are also referred to by their genome groupings. The crop encompasses a range of diploids, triploids and tetraploids. These are categorized into genome groups on the basis of their ploidy levels and the genomes which they contain. Simmonds & Shepherd (1955) suggested that edible bananas originated from two wild and seedy species, *Musa acuminata* ( $2n = 2x = 22$ ) and *Musa balbisiana* ( $2n = 2x = 22$ ), which are native to Southeast Asia, resulting in a series of seedless diploid, triploid and tetraploid bananas. The resulting genome groups were classified as AA, AB, AAA, AAB, ABB, AABB, AAAB, ABBB with the letters A and B representing the contributions of *M. acuminata* and *M. balbisiana* respectively.

The earliest classification of the genus *Musa* L. was that of Sagot (1887), who divided this genus into three unnamed groups (called “sections”): (1) bananas with fleshy fruit, often edible viz. *M. paradisiaca*, *M. sapientum* and *M. troglodytarum*; (2) ornamental bananas with upright inflorescences and brightly coloured bracts viz. *M. ornata*, *M. sanguinea* and *M. coccinea*; and (3) giant bananas like *M. ensete* J.F. Gmel. Baker (1893) adopted Sagot’s division almost unaltered by defining three subgenera: (1) *M. subg. Physocaulis* Baker: stem bottle-shaped, many flowers in a bract, fruits inedible (the type is *M. ensete*, currently accepted in the genus *Ensete* Horan. as *E. edule* Horan.; Horaninov 1862: 40–41); (2) subg. *Rhodochlamys* Baker: stem cylindrical, flowers few to a bract, bracts brightly coloured, fruits usually not edible; (3) subg. “*Eumusa*” Baker: stem cylindrical, flowers many to a bract, bracts green, brown or dull violet, fruits usually edible. Cheesman (1947) developed a clear and coherent classification system for the genus *Musa* His original grouping of

the species in the genus *Musa* into four sections proved to be very useful and has, therefore, been widely accepted, viz. *M. sect. “Eumusa”* Cheesman (*M. sect. Musa*), *M. sect. Rhodochlamys* (Baker) Cheesman, *M. sect. Australimusa* Cheesman and *M. sect. Callimusa* Cheesman.

Cheesman (1947) indicated that “the groups have deliberately been called sections rather than subgenera in an attempt to avoid the implication that they are of equal rank.” He further pointed out that his publication “may stimulate investigation of a genus that is difficult to collect and study, but sufficiently interesting and important in both economic and its more strictly botanical aspects to repay the investigators.”

Argent (1976) later described *Musa sect. Ingentimusa* based on a single species, *Musa ingens* N.W. Simmonds. Chromosome numbers for these five previously proposed sections are as follows: *M. sect. Australimusa*  $2n = 2x = 20$ ; sect. *Callimusa*  $2n = 2x = 20$  (except *Musa beccarii*  $2n = 2x = 18$ ); sect. *Ingentimusa*  $2n = 2x = 14$ ; sect. *Musa* (“*Eumusa*”)  $2n = 2x = 22$  and sect. *Rhodochlamys*  $2n = 2x = 22$  (Cheesman & Larter, 1935; Cheesman & Dodds, 1942; Cheesman, 1947; MacDaniels, 1947; Shepherd, 1959, 1990, 1999; Simmonds, 1962; Champion, 1967; Hotta, 1967; Simmonds & Weatherup, 1990; Isobe & Hashimoto, 1994; Sharrock, 2000; Häkkinen, 2001, 2003a, b, 2004a, b, 2005a, b, 2006a, b, c, 2007, 2009a, b, c, 2011; Jong & Argent, 2001; Wu & Kress, 2001; Häkkinen & Sharrock, 2002; Häkkinen & Meekiong, 2004, 2005; Häkkinen & al., 2005, 2007a, b, 2008, 2009, 2010, 2012; Häkkinen & Wallace, 2007; Häkkinen & Wang, 2007, 2008a, b; Häkkinen & Teo, 2008; Häkkinen & Väre, 2008a, b, c, 2009a, b, 2011; Li & al., 2010; Liu & al., 2010; Nayar, 2010).

### ■ REVISION OF *MUSA* SECTIONS

Many molecular phylogenetic studies on the genus *Musa* (Gawel & Jarret, 1991; Gawel & al., 1992; Ude & al., 2002; Wong & al., 2002, 2003; Jarret & al., 1992; Jarret & Gawel, 1995; Shepherd, 1999; Nwakanma & al., 2003; Bartos & al., 2005; Heslop-Harrison & Schwarzacher 2007; OECD, 2009;

Li & al., 2010; Liu & al., 2010; Nayar, 2010; Christelova & al., 2011; Hřibová & al., 2011; Xavier & al., 2011) demonstrated that none of the five sections of *Musa* previously defined based on morphology was recovered as monophyletic. Only two infrageneric clades could be identified, which corresponded well to the basic chromosome numbers of  $n = x = 11$  and  $n = x = 10/9/7$ , respectively: one clade comprises species from *Musa* sect. *Musa* and sect. *Rhodochlamys* while the other contains species from *Musa* sect. *Callimusa*, sect. *Australimusa* and sect. *Ingentimusa* (i.e., Li & al., 2010: fig. 2; Christelová & al., 2011: fig. 2). Here I have restructured *Musa* species into two sections, sect. *Musa* and sect. *Callimusa*, based on the DNA analyses cited above.

***Musa* L., Sp. Pl.: 1043. 1753** – Type (designated by Green in Sprague, Nom. Prop. Brit. Bot.: 193. 1929): *M. paradisiaca* L., Sp. Pl.: 1043. 1753 – Lectotype (designated by Argent in Regnum Veg. 127: 68. 1993): [icon] “*Musa cliffortiana*” in Linnaeus, *Musa* Cliff.: unnum. pl. 1736

***Musa* L. sect. *Musa***

= *Musa* sect. *Rhodochlamys* (Baker) Cheesman in Kew Bull. 2: 110. 1948 [“1947”] ≡ *Musa* subg. *Rhodochlamys* Baker in Ann. Bot. (Oxford) 7: 205. 1893 – Type (designated by Häkkinen in Nordic J. Bot. 27: 207. 2009): *Musa ornata* Roxb.

– “*Musa* subg. *Eumusa*” Baker in Ann. Bot. (Oxford) 7: 205. 1893 (not validly published, Art. 22.2)

– “*Musa* sect. *Eumusa*” Cheesman in Kew Bull. 2: 108. 1948 [“1947”] (not validly published, Art. 22.2)

The following 33 species are assigned to this section; species marked with an asterisk (\*) were previously placed in *Musa* sect. *Rhodochlamys*.

1. *Musa acuminata* Colla in Mem. Reale Accad. Sci. Torino 25: 394. 1820
2. \**Musa aurantiaca* G. Mann ex Baker in Ann. Bot. (Oxford) 7: 222. 1893
3. *Musa balbisiana* Colla in Mem. Reale Accad. Sci. Torino 25: 384. 1820
4. *Musa basjoo* Iinuma, Somoku-Dzusetsu, ed. 2: 3, t. 1. 1874
5. *Musa celebica* Warb. ex K. Schum. in Engler, Pflanzenr. IV, 45: 22. 1900
6. *Musa cheesmanii* N.W. Simmonds in Kew Bull. 11: 479. 1957 [“1956”]
7. \**Musa chunii* Häkkinen in J. Syst. Evol. 47: 87. 2009
8. *Musa flaviflora* N.W. Simmonds in Kew Bull. 11: 471. 1957 [“1956”]
9. *Musa griersonii* Noltie in Edinburgh J. Bot. 51: 171. 1994
10. *Musa insularimontana* Hayata, Icon. Pl. Formos. 3: 194. 1913
11. *Musa itinerans* Cheesman in Kew Bull. 4: 23. 1949
12. \**Musa kattuvazhana* K.C. Jacob, Monogr. Madras Bananas: 129. 1952
13. *Musa lanceolata* Warb. ex K. Schum. in Engler, Pflanzenr. IV, 45: 19. 1900
14. \**Musa laterita* Cheesman in Kew Bull. 4: 265. 1949

15. \**Musa mannii* H. Wendl. ex Baker in Hooker, Fl. Brit. India 6: 263. 1892
16. *Musa nagensium* Prain in J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 73: 21. 1904
17. *Musa ochracea* K. Sheph. in Kew Bull. 17: 461. 1964
18. \**Musa ornata* Roxb., Fl. Ind. 2: 488. 1824
19. \**Musa rosea* Baker in Ann. Bot. (Oxford) 7: 221. 1893
20. \**Musa rubinea* Häkkinen & C.H. Teo in Fol. Malaysiana 9: 24. 2008
21. \**Musa rubra* Wall. ex Kurz in J. Agric. Soc. India 14: 301. 1867
22. \**Musa sanguinea* Hook. f. in Bot. Mag. 98: t. 5975. 1872
23. *Musa schizocarpa* N.W. Simmonds in Kew Bull. 11: 474. 1957 [“1956”]
24. *Musa shankarii* Subba Rao & Kumari, Fl. Visakhapatnam Distr. 2: 266. 2008
25. \**Musa siamensis* Häkkinen & Rich. H. Wallace in Fol. Malaysiana 8: 62. 2007
26. *Musa sikkimensis* Kurz in J. Agric. Soc. India, n.s., 5: 164. 1878
27. *Musa thomsonii* (King ex Baker) A.M. Cowan & Cowan in J.M. Cowan & A.M. Cowan, Trees N. Bengal: 135. 1929
28. *Musa tomentosa* Warb. ex K. Schum. in Engler, Pflanzenr. IV, 45: 22. 1900
29. *Musa tonkinensis* R.V. Valmayor, L.D. Danh & Häkkinen in Philipp. Agric. Sci. 88: 240. 2005
30. \**Musa velutina* H. Wendl. & Drude in Gartenflora 24: 65. 1875
31. *Musa yamiensis* C.L. Yeh & J.H. Chen in Gard. Bull. Singapore 60: 167. 2008
32. *Musa yunnanensis* Häkkinen & H. Wang in Novon 17: 441. 2007
33. \**Musa zaifui* Häkkinen & H. Wang in Nordic J. Bot. 26: 43. 2008

***Musa* sect. *Callimusa*** Cheesman in Kew Bull. 2: 112. 1948 [“1947”] – Type (designated by Häkkinen in Nordic J. Bot. 27: 207. 2009): *M. coccinea* Andrews

= *Musa* sect. *Australimusa* Cheesman in Kew Bull. 2: 108. 1948 [“1947”] – Type (designated by Christenhusz in Phytotaxa 2: 53. 2009): *M. textilis* Née

= *Musa* sect. *Ingentimusa* Argent in Notes Roy. Bot. Gard. Edinburgh 35: 111. 1976 – Type: *M. ingens* N.W. Simmonds

The following 37 species are assigned to this section; species marked with an asterisk (\*) or a plus (+) were previously placed in *M. sect. Australimusa* or in *M. sect. Ingentimusa*, respectively.

1. \**Musa arfakiana* Argent in Gard. Bull. Singapore 61: 243. 2010
2. *Musa azizii* Häkkinen in Acta Phytotax. Geobot. 56: 29. 2005
3. *Musa barioensis* Häkkinen in Acta Phytotax. Geobot. 57: 57. 2006
4. *Musa bauensis* Häkkinen & Meekiong in Syst. Biodivers. 2: 170. 2005 [“2004”]

5. *Musa beccarii* N.W. Simmonds in Kew Bull. 14: 200. 1960
6. \**Musa boman* Argent in Notes Roy. Bot. Gard. Edinburgh 35: 108. 1976
7. *Musa borneensis* Becc., For. Borneo: 622. 1902
8. \**Musa bukensis* Argent in Notes Roy. Bot. Gard. Edinburgh 35: 101. 1976
9. *Musa campestris* Becc., For. Borneo: 622. 1902
10. *Musa coccinea* Andrews, Bot. Repos. 1: t. 47. 1799
11. *Musa exotica* R.V. Valmayor in Philipp. Agric. Sci. 87: 117. 2004
12. \**Musa fitzalanii* F. Muell., Fragm. 9: 188. 1875
13. *Musa gracilis* Holtum in Kew Bull. 5: 154. 1950
14. *Musa haekkinenii* N.S. Lý & Haev. in Phytotaxa 75: 35. 2012
15. *Musa hirta* Becc., For. Borneo: 624. 1902
16. +*Musa ingens* N.W. Simmonds in Kew Bull. 14: 198. 1960
17. \**Musa jakeyi* W. Hill, Rep. Brisbane Bot. Gard.: 7. 1874
18. \**Musa johnsii* Argent in Gard. Bull. Singapore 53: 1. 2001
19. \**Musa juwiniana* Meekiong, Ipor & Tawan in Fol. Malaysiana 9: 110. 2008
20. *Musa lawitiensis* Nasution & Supard. in Bul. Kebun Raya 8: 128. 1998
21. *Musa lokok* Geri & Ng in Gard. Bull. Singapore 57: 279. 2005
22. \**Musa lolodensis* Cheesman in Kew Bull. 5: 27. 1950
23. *Musa lutea* R.V. Valmayor, L.D. Danh & Häkkinen in Philipp. Agric. Sci. 87: 116. 2004
24. \**Musa maclayi* F. Muell. ex Mikl.-Maclay in Proc. Linn. Soc. New South Wales 10: 355. 1885
25. *Musa monticola* M. Hotta ex Argent in Gard. Bull. Singapore 52: 206. 2000
26. *Musa muluensis* M. Hotta in J. Jap. Bot. 42: 345. 1967
27. *Musa paracoccinea* A.Z. Liu & D.Z. Li in Bot. Bull. Acad. Sin. 43: 77. 2002
28. \**Musa peekelii* Lauterb. in Bot. Jahrb. Syst. 50: 306. 1913
29. *Musa sakaiana* Meekiong, Ipor & Tawan in Fol. Malaysiana 6: 132. 2005
30. *Musa salaccensis* Zoll. ex Backer, Handb. Fl. Java 3: 133. 1924
31. *Musa splendida* A. Chev. in Rev. Bot. Appl. Agric. Trop. 14: 517. 1934
32. \**Musa textilis* Née in Anales Ci. Nat. 4: 123. 1801
33. \**Musa troglodytarum* L., Sp. Pl. ed. 2: 1478. 1763
34. *Musa tuberculata* M. Hotta in J. Jap. Bot. 42: 347. 1967
35. *Musa violascens* Ridl. in Trans. Linn. Soc. London, Bot. 3: 384. 1893
36. *Musa viridis* R.V. Valmayor, L.D. Danh & Häkkinen in Philipp. Agric. Sci. 87: 115. 2004
37. *Musa voonii* Häkkinen in Acta Phytotax. Geobot. 55: 80. 2004

## ■ CONCLUSION

Beyond this revised sectional classification, the infrageneric taxonomy of *Musa* could be further clarified from additional phylogenetic studies that have a broader sampling of species. Much of the diversity in the two sections is found in

areas of continental Asia that have been, and continue to be, difficult, and sometimes even dangerous, to travel and work in. There are still new *Musa* species observed by the author in those areas awaiting description or clarification.

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