MEIOSIS IN SEEDED DIPLOIDS OF *MUSA*

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I. Introduction

A new classification of *Musa* has recently been published by Cheesman (1948), in which he divides the genus into four sections as follows:

Chromosome number $x=11$. Bracts more or less sulcate, often more or less glaucous, rarely or never polished, convolute or more or less imbricate in the bud, usually strongly revolute on fading. Seeds occasionally subglobose, more often dorsiventrally compressed, sometimes lenticular, smooth tuberculate, or irregularly angulate, with a marked or obsolete umbo opposite to the hilum.

1. Inflorescence pendent or semi-pendent from the first, the fruits reflexing in development towards the base of the rachis. Flowers many to a bract, in two series. Bracts commonly dull-coloured, green, brownish or dull purple. Pseudostems commonly exceeding 3 m. high. Section: Eumusa

2. Inflorescence erect, at least at the base, so that the fruits do not reflex in development but point towards the apex of the rachis. Flowers few to a bract, usually in a single series. Bracts brightly coloured, often red. Pseudostems commonly less than 3 m. high. Section: Rhodochlamys

Chromosome number $x=10$. Bracts plane, firm in texture, polished on the outside, rarely or never glaucous, strongly imbricate in the bud, not or only slightly revolute on fading.

3. Seeds subglobose or more or less dorsiventrally compressed, smooth, striate, tuberculate, or irregularly angulate, with a marked or obsolete umbo opposite to the hilum corresponding to a small perisperm chamber within. Section: Australimusa

4. Seeds cylindrical, barrel-shaped, or top-shaped, marked externally by a transverse line or groove, above which they are warted; tuberculate or variously patterned, below usually smooth; internally with a well-developed perisperm chamber above the same line, this chamber empty in the ripe seed. Section: Callimusa

In this paper an account is given of the meiotic behaviour of various species representative of each of these sections. It may be noted that the edible forms discussed in previous publications are members of *Eumusa*; none of them is considered here.

II. Cytological data

Section Eumusa. *Musa acuminata* Colla is a very variable species that occurs in Assam, Burma, the Malay Peninsula and Archipelago, Siam, Indo-China and the Philippines. We have material of known history from Assam, Burma, Java, Malaya and Annam. In Table 1, the provenance of each of our clones and data from its first division of meiosis are given. With the exception of Clone E and one cell of Clone Buitenzorg, the only meiotic irregularities were the occasional failure of the formation of a bivalent (in Clones B, D, G, Long Tavoy and Mariani) and the presence of an inversion (in Clones B, Annam, Mariani and Assam A). Such slight irregularities are to be expected in an outbred group.

The exceptional Clone E was established from seeds received from the Botanic Gardens at Buitenzorg. Data for its first metaphases and first anaphases are as follows:

	Univalents at first metaphase					
	2	4	6	8	Total	
Cells	11	4	4	1	20	Univalents per cell = 3·5

	First anaphase			
	Regular and with lagging univalents	Bridge and fragment (B.f.)	Total	
Cells	30	21	51	B.f. per cell = 0·41

The metaphase data agree quite well with those of Wilson (1946) who found a mean of 4·3 univalents per cell; but he did not observe any bridges and fragments at anaphase. The data suggest that this clone might well be a natural species hybrid. However, the spiralization of its chromosomes during prophase and their orientation at metaphase were regular, in marked contrast to the mistiming usually observed in experimental hybrids. The latter, with a similar amount of failure of pairing, are virtually male sterile (Dodds

Table 1. *Meiosis in the* Musa acuminata *complex*

			First metaphase		First anaphase		
Clone	Introd. Reg. no.	Provenance	Univalents per cell	Nos. of cells	Bridge and fragment per cell	Bridge only per cell	Nos. of cells
A (Selangor)	I.R. 53	Malaya	0·0	25	0·00	0·00	52
B*	I.R. 6	Trinidad, B.W.I.	0·9	20	0·020	0·00	50
D*	I.R. 84	Java	0·2	20	0·00	0·00	56
E*	I.R. 85	Java	3·5	20	0·412	0·00	51
G*	I.R. 55	Canary Islands	0·2	20	0·00	0·00	55
L	I.R. 109	Malaya	0·0	40	0·00	0·00	52
Buitenzorg*	I.R. 205	Java	0·0	21†	0·00	0·00	102
Calcutta 4*	I.R. 124	India	0·0	50	0·00	0·032	221
Tavoy	I.R. 187 A	Burma	0·0	20	0·00	0·00	50
Long Tavoy	I.R. 187 B	Burma	0·1	20	0·00	0·00	101
Annam	I.R. 144	Indo-China	0·0	20	0·020	0·00	50
Mariani	I.R. 209	Assam	0·1	62	0·008	0·058	362
Assam A	I.R. 241	Assam	0·0	20	0·19	0·00	156
Assam B	I.R. 242 F	Assam	0·04	20	0·00	0·00	75

* Material from botanic gardens; previous history unknown.
† One exceptional metaphase excluded (see text).

& Pittendrigh, 1946; Dodds & Simmonds, 1946), whereas Clone E produces a good deal of viable pollen. Moreover, Clone E shows phenotypically no evidence of hybridity. It seems probable, therefore, that in Clone E asynapsis of the chromosomes rather than hybridity is responsible for failure of pairing. This was more certainly the case with the sporadic behaviour of Clone Buitenzorg wherein a single cell was observed with six bivalents and ten univalents.

The Mariani form (Cheesman, 1948) of *M. acuminata* is as yet only tentatively included within the species. Within it, the only meiotic irregularity, other than a persistent nucleolus (Simmonds & Dodds, 1947), was rare failure of pairing (Mariani and Assam B) and inversion hybridity (Mariani and Assam A; Table 1).

M. Banksii F. v. Muell. occurs in Queensland, at the south-western extremity of the range of *M. acuminata*, which species it closely resembles both in habit and floral characters. It is retained as a distinct species by Cheesman (1948) for convenience rather than from

conviction, but it seems likely that transitional forms between the two await collection in New Guinea or the Moluccas. The only meiotic irregularity in our surviving representative (Clone Bloomfield; Table 2) was the occasional failure of the formation of a bivalent.

M. Balbisiana Colla is the most widely distributed species of the genus. It is found, with very little apparent variation through its range, in Ceylon, India, Burma, Siam, Malaya, Java, the Philippines and New Guinea. In the three clones that have been examined, meiosis was regular (Table 2).

M. Basjoo Sieb. is one of the best known species of the genus because it is often grown in temperate glasshouses owing to its tolerance of a cool climate. The species is indigenous to the Liukiu Archipelago. Our clone has a regular meiosis (Table 2).

M. itinerans Cheesm. from Upper Burma is described from the material in our collection. It is regular at meiosis (Table 2).

Table 2. *Meiosis in species of* Musa *with* $2n = 22$

				First metaphase		First anaphase		
Species	Clone	Introd. Reg. no.	Provenance	Univalents per cell	Nos. of cells	Bridge and fragment per cell	Bridge only per cell	Nos. of cells
M. Banksii	Bloomfield	I.R. 139	Queensland	0·2	20	0·00	0·00	51
M. Balbisiana	Ceylon	I.R. 100	Ceylon	0·0	20	0·00	0·00	50
	Martini*	I.R. 163	Belgian Congo	0·0	20	0·00	0·00	55
	Assam C	I.R. 242	Assam	0·0	22	0·00	0·00	50
*M. Basjoo**	—	I.R. 78A	Devonshire	0·0	20	0·00	0·00	96
M. itinerans	—	I.R. 185	Burma	0·0	20	0·00	0·00	60
M. ornata	A*	I.R. 1	Trinidad, B.W.I.	0·2	20	0·00	0·00	50
M. laterita	—	I.R. 225	Burma	0·0	20	0·00	0·00	50
*M. sanguinea**	—	I.R. 207	Java	0·5	20	0·00	0·00	52
M. velutina	—	I.R. 212	Assam	0·0	20	0·02	0·00	51
	Kermode†	I.R. 188A	Burma	3·6	20	0·00	0·00	53

* Material from botanic gardens; previous history unknown.
† See text.

Cheesman (1948) mentions a plant raised from seed received from Burma, and, on taxonomic grounds, suggests that it is a natural hybrid between *M. nagensium* Prain. and *M. Balbisiana*. Metaphases of this material were very difficult to analyse as a result of errors of spiralization and misorientation. Its meiosis was irregular and gave the following data:

	Univalents at first metaphase									
	0	2	4	6	8	10	12	14	Total	
Cells	4	6	6	1	2	0	0	1	20	Univalents per cell = 3·6

Numerous univalents were present at anaphase but no bridges were observed. The data confirm the view that this plant (Clone Kermode) is, indeed, a natural interspecific hybrid.

Section RHODOCHLAMYS. *M. ornata* Roxb. figures as an ornamental plant in many tropical gardens. Apart from the occasional failure of the formation of a bivalent, meiosis in our clone is regular. Similarly, only minor irregularities were observed in *M. sanguinea* Hook and *M. velutina* Wendl. & Drude, natives of Assam. In the former, there were occasional univalents at metaphase and the latter was heterozygous for an inversion. *M. laterita* Cheesm., from Burma, was regular at meiosis (Table 3).

Section AUSTRALIMUSA. *M. textilis* Née is probably a native of the Philippines. One of twenty cells at metaphase contained two univalents (Table 3). *M. Peekelii* Lauterb., from

New Guinea, was exceptional. Its first divisions were mistimed and difficult to analyse but the following data were obtained:

	Univalents at first metaphase								
	0	2	4	6	8	10	12	Total	
Cells	7	7	4	0	0	1	1	20	Univalents per cell = 2·6

	First anaphase		
	Regular or with lagging univalents	Bridge	Total
Cells	77	4	81

These data suggest interspecific hybridity, but in the absence of detailed taxonomic knowledge of this section, we cannot suggest putative parents.

M. lolodensis Cheesm., from the Moluccas, was regular at metaphase, but rare bridges without fragments were observed at first anaphase.

Section Callimusa. Both *M. Borneensis* Becc. from North Borneo and *M. coccinea* Andr. showed a regular meiosis. The latter occurs in southern China, Cochin China, Sumatra and Java and is now widely distributed in the botanical gardens of Europe. *M. violascens* Ridl. of Malaya was regular at metaphase, but rare bridges without fragments occurred at first anaphase (Table 3).

Table 3. *Meiosis in species of* Musa *with* $2n = 20$

				First metaphase		First anaphase		
Species	Clone	Introd. Reg. no.	Provenance	Univalents per cell	Nos. of cells	Bridge and fragment per cell	Bridge only per cell	Nos. of cells
*M. textilis**	St Vincent	I.R. 71	St Vincent, B.W.I.	0·1	20	0·00	0·00	100
M. Peekelii	—	I.R. 229	New Ireland	2·6	20	0·00	0·049	81
M. lolodensis	—	I.R. 247	Halmahera	0·0	20	0·00	0·04	101
M. Borneensis	—	I.R. 118	Sarawak	0·0	20	0·00	0·00	29
*M. coccinea**	—	I.R. 142	Trinidad, B.W.I.	0·0	20	0·00	0·00	20
M. violascens†	—	I.R. 108	Malaya	0·0	5	0·00	0·09	34
Indet.	New Guinea 384	I.R. 194	New Guinea	0·0	14	0·00	0·10	50
Indet.	Buka B	I.R. 201	New Guinea	0·0	20	0·00	0·08	50

* Material from botanic gardens; previous history unknown.

† Numerous metaphases were regular as to pairing, though extreme tensions rendered analysis difficult.

These two sections, *Australimusa* and *Callimusa*, are the least known, taxonomically, of the genus, for their members tend to occur in the more remote parts of the range of *Musa*. They do not grow well under Trinidad conditions, being very susceptible even to mild drought, and we have difficulty in raising them to the flowering stage. At metaphase, strong tensions are developed within the bivalents, giving a very characteristic general appearance to the plate, which is quite distinct from that of the other two sections of the genus. It will be noted that all the bridges lacked observable fragments (Table 3); they might have resulted either from structural hybridity of the chromosomes or from an atypical nucleic acid metabolism.

III. SUMMARY AND CONCLUSIONS

Meiosis is described in species of four sections of *Musa*, namely, Eumusa and Rhodochlamys with $2n = 22$, and Australimusa and Callimusa with $2n = 20$. It was essentially regular in most, although rare failure of pairing and inversion hybridity were found. There is no evidence of interchange—an interesting observation in view of the fact that this type of hybridity is characteristic of the edible diploid complex of Eumusa (Dodds, 1943; Dodds & Simmonds, 1948).

In three plants, clones of *M. acuminata* (Eumusa), *M. Peckelii* (Australimusa) and in the clone Kermode (Eumusa) pairing was low and irregular. Only the last named could confidently be identified as an interspecific hybrid. The other two gave no phenotypic evidence of hybridity, and failure of pairing might have resulted from asynapsis.

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