Diversity and distribution of section Rhodochlamys (Genus *Musa*, Musaceae) in India and breeding potential for banana improvement programmes

S. Uma,✉ M.S. Saraswathi, P. Durai, and S. Sathiamoorthy
Division of Crop Improvement, National Research Centre for Banana, Thogamalai Road, Thayanur Post, Trichy-620 102, Tamil Nadu, India. Corresponding author's e-mail: umabinit@yahoo.co.in

Summary

Diversity and distribution of section Rhodochlamys (Genus *Musa*, Musaceae) in India and breeding potential for banana improvement programmes

The Indian flora has a wide spectrum of diversity for banana and plantains (*Musa* spp.), belonging to the sections Eumusa and Rhodochlamys. Eumusa comprises most of the cultivated commercial and food varieties, while Rhodochlamys is known for its many ornamental species. The present article is a review of the Rhodochlamys diversity in India, based on recent explorations where special attention was paid to the habitat of the species. A tentative key was developed for the identification and classification of Rhodochlamys members in India. A number of variants were noticed, and their status as natural or artificial intersectional 'Eumusa × Rhodochlamys' hybrids is discussed.

Key words: *Musa*, banana, Rhodochlamys, breeding, diversity

Résumé

Diversité et distribution de la section Rhodochlamys (Genus *Musa*, Musaceae) en Inde et potentiel de sélection pour les programmes d'amélioration du bananier

La flore indienne présente une grande diversité de bananiers et de plantains (*Musa* spp.), appartenant aux sections Eumusa et Rhodochlamys. Eumusa comprend la plupart des variétés commerciales et vivrières cultivées, tandis que Rhodochlamys est connu pour ses nombreuses espèces ornementales. Le présent article est une revue sur la diversité de Rhodochlamys en Inde, basée sur des explorations récentes et dans laquelle une attention particulière a été accordée à l'habitat des espèces. Une tentative de clé a été élaborée pour l'identification et la classification des membres de Rhodochlamys en Inde. De nombreux variants ont été observés, et leur statut en tant qu'hybrides naturels ou artificiels à l'intersection « Eumusa × Rhodochlamys » est discuté.

Resumen

Diversidad y distribución de la sección Rhodochlamys (género *Musa*, Musaceae) en la India y posibilidades de fitomejoramiento en los programas de mejoramiento del banano

La flora de la India presenta un amplio espectro de diversidad de bananas y plátanos (*Musa* spp.) pertenecientes a las secciones Eumusa y Rhodochlamys. Eumusa comprende la mayor parte de las variedades comerciales y de alimentación cultivadas, mientras que Rhodochlamys es reconocida por sus numerosas especies ornamentales. Este artículo es un examen de la diversidad de Rhodochlamys en la India, basado en recientes exploraciones donde se dedicó particular atención al hábitat de las especies. Se desarrolló una clave tentativa para identificar y clasificar a los miembros de Rhodochlamys en la India. Se encontró cierta cantidad de variantes y se debate su *status* como híbrido interseccional 'Eumusa × Rhodochlamys' natural o artificial.

Introduction

The family of the Musaceae is known not only for edible bananas but also for other uses. There are two genera in this family: *Musa* and *Ensete*. A recent proposal to include *Musella* as a third genus has not yet been confirmed due to controversy (Daniells et al. 2001). Based on basic chromosome numbers and morphological characters, the *Musa* species have been grouped into four sections: Eumusa, Rhodochlamys, Australimusa and Callimusa, together with a group of ill-defined species enigmatically termed *Incertae sedis*. Eumusa and Rhodochlamys have a basic chromosome number of 2n=22, Australimusa and Callimusa have 2n=20, while the *Incertae sedis* have 2n=14 and 18 (*M. ingens* and *M. beccari*, respectively) (Simmonds 1962).

Rhodochlamys is closely related to Eumusa based on genetic affinity (Shepherd 1999). The section comprises several valuable ornamental bananas of commercial importance.

A considerable amount of work has studied the origin, distribution and taxonomy of various Eumusa species, and this has been reviewed by Singh and Chadha (1993) and Singh and Uma (2000) for the work in India. In sharp contrast, reports on Rhodochlamys have been scanty and date from the early 1920s to the 1950s. Recently, the taxonomy of the section Rhodochlamys has been revisited and many of the doubts raised in the earlier reports are being resolved. This article is an effort to redefine the distribution of the section Rhodochlamys in India, based on both earlier literature and the authors' recent explorations.

General characteristics

Members of the Rhodochlamys section are slender and delicate plants, found growing from sea level to 1200 m. Short to medium in stature (1.0–2.5 m), they bear an erect inflorescence with a short peduncle, of which the hands are uniseriately arranged. Fingers are short to medium, sometimes dehiscent upon maturity, and usually female fertile. The wide range of bright coloured bracts is characteristic for the section.

General distribution

Rhodochlamys members are native to tropical evergreen forests and moist rain (monsoon) forests of south and south-east Asia. Interestingly, they are highly adaptive to

extremities of drought and temperature; aerial parts tend to wilt and disappear altogether, and new pseudostems sprout up from the rhizome after the first new rains. Outside India, their distribution is confined to a rather restricted area that includes Myanmar, Bangladesh and north-west Thailand. China has been reported for *M. sanguinea* in western Yunnan (Liu et al. 2002), but it is suggested that the plant was introduced to China several centuries ago as cultivated material (Hakkinen and Sharrock 2002). In India, and although Rhodochlamys members have been, recorded from south-western to north-eastern Indian states, most diversity and distribution in the wild is reported from Arunachal Pradesh, the state bordering China and Myanmar. Occurrence of Rhodochlamys species, selected as ornamentals, has been reported from time to time (Carey 1824; Chakravorti 1948; Sundararaj and Balasubramanyam 1952; Jacob 1952; Uma et al. 2002).

Materials and methods

Explorations were conducted by the authors in twelve Indian states, including the Andaman and Nicobar Islands, where banana has originated and distributed, in collaboration with State Agricultural Universities, State Forest Departments, Indian Council for Agricultural Research (ICAR) Institutes and NGOs. Specimens were collected and described, and subsequently planted in the field gene bank of the National Research Centre for Banana (NRCB) for further evaluation. General rainfall pattern, temperature and vegetation types of explored areas are shown in Table 1.

Results and discussion

The explorations suggest that, in India, Rhodochlamys has a distribution from mean sea level up to an elevation of 1500 m in areas where mean temperatures range between 10° and 28 °C. They are found in tropical evergreen forest to moist evergreen forest. In general, these sensitive plants prefer a mild climate, a well-drained soil rich in humus, and rainfall of 1500–3000 mm/yr, distributed throughout the year. The areas covered by the explorations and the occurrence of species are summarized in Table 2. In all, seven species, three possible mutants and two intersectional hybrids (Eumusa × Rhodochlamys) were found.

Musa ornata *Roxb.*

Musa ornata Roxb. was originally listed by Roxburgh (1814) by name only, and the original description occurs in his *Flora Indica* edited by William Carey and published in 1824, and definitely classified by Cheesman (1949), followed by Sundararaj and Balasubramanyam in 1952, and reviewed by Hakkinen and

Table 1. Ecological parameters and the vegetation types of the areas explored

State	Rainfall (mm/yr)	Temperatures	Vegetation type
Meghalaya	2000–4000	23°–26°C max 12°–17°C min	Pine forest, Deciduous pine forest, Evergreen forest, Tropical moist forest
Arunachal Pradesh	2950–3000	30°–35°C max 0°–6°C min	Tropical evergreen, Semi-evergreen, Deciduous forest, Subtropical forest, Wet temperate forest.
Assam	3200–3500	32°–37°C max 6°–15°C min	Tropical semi-evergreen forest, Tropical moist forest, Dry deciduous
Manipur	1450–2077	32°–34°C max 6°–18°C min	Subalpine forest, Wet temperate forest
Nagaland	1800–2000	25°–30°C max 4°–25°C min	Dry deciduous forest, Subtropical forest
Tripura	1700–1800	19°–33°C max 10°–19°C min	Deciduous forest, Moist tropical forest
Mizoram	1900–2500	18°–32°C max 6°–18°C min	Bamboo forest, Moist tropical forest
Kerala	1500–2100	18–24°C max 16°–18°C min	Tropical evergreen forest
Karnataka	1600–2200	20°–30°C max 10°–15°C min	Wet evergreen forest, Moist deciduous forest
Andhra Pradesh	1500–1800	30°–34°C max 5°–26°°C min	Tropical and Subtropical forests
Tamil Nadu	800–1100	20°–30°C max 10°–20°C min	Moist evergreen, Dry and deciduous forest
Andaman and Nicobar Islands	3000–3800	22°–30°C max 20°–23°C min	Tropical evergreen forest

Table 2. Distribution of Rhodochlamys members in India

State	Area covered	Species found
Assam	Jorhat, Khasi hills, Dhipu, Namsai forest, Margharetta forest range, Lakhimpur, Kaziranga, Dibrugarh and Digboi	*M. laterita*
Arunachal Pradesh	Itanagar, Balukpong, Tippi, Sessa, Bomdilla, Kimin, Yajali Ziro Raga, Godak, Daporijo, Tirbin, Bame, Basar, Doke, Along	*M. velutina, M. rosacea, M. aurantiaca, M. laterita, M. sanguinea*
Megalaya	Shillong, Umiam, Khasi hills, Barapani and Nonbogh, Mawphlang	*M. laterita*
Manipur	Imphal, Noney, Awang khool, Irang, Themenglong khungsong, Seikmai, Tadugi	*M. rosacea, M. ornata*
Nagaland	Senapathi, Kohima, Pherima, Piphema, Dimapur, Paglapahad and Naga Hills	*M. laterita*
Tripura	Agartala, Ambassha, Bishal Nagar, Udaipur, Kumarghat, Dharmangar, Karimganj	*M. ornata* (Chittang forest)
Mizoram	Aizawl, Seling, Mizo hills and Janitia hills, Kolasib, Lunglei	*M. rosacea, M. rubra*†
Andhra Pradesh	Vishakapatnam and Arakku valley	*M. ornata*
Tamil Nadu	Kolli hills, Pacha Malai, Shevoroy hills, Pechiparai and KMTR (Kalakkadu Mundanthurai Tiger Reserve forest)	*M. laterita*‡
Karnataka	Northern Karnataka, Belgaum, Dharwad, Sirsi and Western Ghats of Karnataka	*M. laterita*‡
Kerala	Attappady valley and Anamalai, Palakkad, Trivandrum and Idukki	*M. laterita*‡
Andaman and Nicobar Islands	Middle and South Andaman, Rut Island, Bamboo Flat, Mount Harriet, Havelock.	None

Notes: † The explorations found no occurrence of *M. rubra* in any of the NE states. However, the Indian Institute of Horticultural Research (IIHR), Bangalore, India, has a collection from the Indo-Myanmar border. ‡ The reports of Jacob (1952) note occurrence in moist evergreen forests of the Western Ghats of the former Madras Province (including Tamil Nadu, Kerala and Karnataka), but identified not as *M. laterita* but as 'Kattu Vazha'.

Sharrock (2002). None of our collections exhibited the pink midrib of the leaves shown in the Hakkinen and Sharrock (2002) review and the specimen in that photograph could be a natural hybrid owing to the high cross-compatibility of the species within and between sections.

Abraham et al. (1976) mentioned the height of the plant as about 1.0 m, but the common height is approximately 1.7 to 1.8 m. The *Musa* field gene bank at NRCB, Trichy, also has an accession collected from Banana Research Station, Kannara, India, Kannara, Kerala, labelled *M. ornata* and similar to the Abraham description, but the identity of these quite small types needs to be further investigated.

Shepherd (1999) suggested the status of secondary hybrids for *M. ornata* as a result of a cross between *M. flavifera* and *M. velutina.* Simmonds (1954) was indeed of the opinion that all Rhodochlamys members have a hairy peduncle, while *M. ornata* is a unique member with a distinct glabrous peduncle.

Our explorations also agreed with the observations of Sundararaj and Balasubramanian (1952) regarding the narrow distribution of *M. ornata*—limited to the Arakku valley. Though its distribution has been mentioned in the Chittagong forests of Tripura (Carey 1824), the area was not accessible to the current expedition due to civil unrest, rough terrain and remoteness.

Musa rosacea *Jacq.*

Musa rosacea Jacq. has a wide distribution in the tropical evergreen forests of Arunachal Pradesh and Mizoram. Generally, *M. rosacea* and *M. aurantiaca* have a common distribution pattern in the Arunachal Pradesh forests, where long stretches of *M. nagensium* are interspersed by patches of *M. aurantiaca* and *M. rosacea* at regular intervals.

Confusion between *M. rosacea* and *M. ornata* has long existed owing to the similar colour of the male bracts, i.e. pale lilac, and was reviewed by Hakkinen and Sharrock (2002). Simmonds recorded the height of *M. rosacea* to be 1.0 to 1.5 m.

Our exploration in the north-eastern states has clearly indicated or confirmed a few major differences between *M. ornata* and *M. rosacea.* The distribution of *M. ornata* is restricted to lower elevations, 100–150 m, while *M. rosacea* can be found up to 800 m. *M. rosacea* grows to more than 1.8–2.0 m, while *M. ornata* has a maximum height of 1.5 m. Another distinct feature is the petiolar length: *M. rosacea* has a slender petiole of 1.25 m, while *M. ornata* has a short petiole of 0.45–0.60 m. The male axis is slender, short (0.40–0.50 m), with a degenerating male bud, indicated by a reducing number of male flowers in each bract, as in False Horn Plantain (AAB). The internodal spacing also drastically reduces, giving a tapering look to the male axis. In contrast, *M. ornata* has a

fairly robust male bud and glabrous peduncle, maintaining its circumference along its total length of 0.75–1.0 m.

The recent description of *M. rosacea* with a pink bract and yellow tip (Singh et al. 2001) seems to apply only to a patch in Arunachal Pradesh. All the collections made by the authors from four different areas of the natural distribution exhibited a pale lilac bract without a yellow tip.

Musa laterita *Chees.*

Musa laterita Chees. is the most common of *Musa* ornamental plants and is widely distributed worldwide. It originates from north-eastern India, Myanmar and north-west Thailand. The name 'laterita' derives from the bright, brick-red colour of the bracts, resembling laterite soil (Hakkinen 2002). Its distribution is mostly from sea level up to only 150 m. It is frequent in home gardens of Karnataka, Assam and Meghalaya states, as an ornamental plant. Very characteristic rhizomatous underground roots stretch over 1.0–1.5 m, as is the case with *M. itinerans* of the section Eumusa.

There also exists a small (dwarf) variant, which morphologically closely resembles *M. laterita*. It exhibits a plant height of less than 1 m, with more elongated leaves of 1.0 m or more in length and 20–25 cm in width. The sword-shaped leaves stand typically erect and clustered. Suckering is profuse. The peduncle is short (15–20 cm) with 4–5 uniseriate flowers. The male bract is bright reddish-pink in colour. The golden tip of the bract resembles that of *M. rubra*. Though the occurrence of the dwarf species has been mentioned by Abraham (1976), it has been wrongly documented as *M. ornata*.

The field gene bank of the Banana Research Station, Kannara, India, also has this dwarf accession under the name of *M. ornata*. exhibiting the rhizomatous roots of *M. laterita*, but the species status needs confirmation. Since most of the plant characters resemble that of *M. laterita*, this could be a dwarf ecotype of *M. laterita*.

Musa velutina *Wendl.*

M. velutina is considered to be the most beautiful member of Rhodochlamys, with its pinkish-red dehiscent fruits. Unlike other Rhodochlamys members, this is medium to tall, growing to a height of 2.0–2.5 m in undisturbed conditions.

Its distribution is more in lower altitudes across Arunachal Pradesh, from West Kemeng District (in the west) to Lohit District (in the east), and bordering Assam in the Balipara area. It has become a menace as a weed in agricultural fields due to its fast suckering and spreading habit. The attractive colour of the fruit and its dehiscent nature promotes seed dispersal through birds and bats, favouring its rapid spread. It grows wild in the subtropical evergreen forests of Arunachal Pradesh and Assam.

Variants or hybrids

During our explorations, a new type, close to *M. velutina*, was observed in Ziro, Raga, Godak and Daporijo areas of Arunachal Pradesh. Its wide distribution suggests a natural origin. It differs from *M. velutina* for several traits. It has a deep-pink-coloured male bud, while *M. velutina* has a rose-pink coloured bract with deep pink margins. Likewise, deep-pink-coloured fruits, while *M. velutina* has rose-pink-coloured fruits. The bunch has 4–6 spaciously arranged hands with an internodal spacing of 5–6 cm and a male inflorescence extending over 30–50 cm. *M. velutina* has very compactly arranged hands and the male inflorescence is only 20–25 cm long.

For the time being, its exact status remains undetermined. Compatibility with other members of Rhodochlamys and of Eumusa could have led to the development of a natural hybrid. The wide distribution, however, suggests an older origin and perpetuation under favourable conditions, all indicating stabilization as a variant.

Another plant with an *M. velutina*-like male bud and female phase was noted in Basar, Bame, Along and nearby areas of East Kemeng Districts of Arunachal Pradesh. It is not sympatric with the *M. velutina sensu stricto*, which suggests the migration of this type to other favourable places in Arunachal Pradesh. These two types were noted only in Arunachal Pradesh.

Musa aurantiaca *Mann.*

Musa aurantiaca Mann. is an elegant member of *Rhodochlamys*, with bright-orange-coloured buds. It has a wide distribution across Arunachal Pradesh from west to east, but was seen mostly at higher altitudes (wet temperate forest of upper Assam). *M. aurantiaca* has highly prolific suckering and each clump consists of 25–30 pseudostems under undisturbed condition. The clump is in flower at any given time of the year, with 4–5 buds as a group giving a false appearance of forest flame. It co-exists freely with *M. rosacea*, but natural hybrids were not noted. Both species are found along watercourses and in moist areas. In general, climatic factors, especially altitude, have an effect on plant pigmentation.

A new type of *M. aurantiaca* with variant characteristics (see Table 3) was found during our exploration trip. This could be a simple ecotype or a natural mutant.

Musa sanguinea *Hook*

Musa sanguinea Hook is widely distributed in higher altitudes of Arunachal Pradesh, in areas like Ziro, Raga, Godak, Laa and Gami. *M. sanguinea* seems to grow sympatrically with *M. aurantiaca* and *M. rosacea*. Occurrence is mostly along watercourses and marshy areas. The plants are attractive due to bright red bracts.

Distribution pattern of Rhodochlamys members in India

Detailed explorations in various states revealed an endemic nature for most Rhodochlamys species in north-east India. However, reports of *M. laterita* in the Western Ghats of Kerala and Karnataka (Jacob 1952); occurrence and distribution of *M. ornata* in Arakku Valley of Andhra Pradesh in the

Table 3. Differences between *Musa aurantiaca* and a variant ecotype found during the expedition

Characters	Typical *Musa aurantiaca*	Ecotype
Colour of peduncle and male axis	green	green with orange shade
Colour of style and size of stigma	green; bold	green; rudimentary or aborted
Nature of male bud	alive even after bunch maturation	degenerates before bunch maturation
Immature fruit colour	green	green with orange shade

Eastern Ghats (Sundararaj 1952); and our explorations suggest occurrence and distribution of species of the section Rhodochlamys even in southern states of India.

Surprisingly, detailed exploration in North and Central Andaman islands found no species in section Rhodochlamys. Though the Nicobar Islands have not been covered, discussion with local personnel from the Botanical Survey of India and the State Agricultural Departments strengthened the authors' views that Rhodochlamys does not occur in the Andaman and Nicobar Islands. The areas covered are shown in the map in Figure 1. Their geographical isolation from the Indian mainland is a probable reason.

The overall details of the distribution of Rhodochlamys members in India are shown in Table 2.

Based on the authors' findings, combined with oral information from local tribes and Forest Department personnel, as well as earlier reports, maps have been prepared to show the distribution (Figure 1).

Provisional determination key for the section Rhodochlamys in India

The problem of synonymy and the numerous names for particular species are a major source of confusion in this section. Wide diversity, difficultly of access to the distribution areas and limitations in the descriptions of species (poor illustrations) have all added to the confusion. Though the Sharrock and Hakkinen review (2002) attempted to overcome this, the section Rhodochlamys still needs more systematic exploration, collection and authentication – both descriptive and by using molecular characterization techniques. An attempt is made here to provide a taxonomic key based on morpho-taxonomic characters for the identification of the members of Rhodochlamys studied by the authors (Figure 2). Stature of the plant, colour of the bract, nature of fruit skin, length of the petiole, appearance of the male bud and bracts are the prominent morphological characters (Singh et al. 2001).

Genetic behaviour and breeding potential

Rhodochlamys shares with Eumusa the chromosome number 2n=22. Genetic relatedness has been proved by many researchers (Carreel 1994; Jarret and Gawel 1995; Wong *et al.* 2001). Indeed, the distribution area of Rhodochlamys overlaps with that of several Eumusa members in India (Uma et al. 2000), with an amazing diversity in bud colour (see colour photo online at http://www.ipgri.cgiar.org/pgrnewsletter/default.asp?id_issue=146).

The authors' explorations indicated the co-existence of Rhodochlamys members such as *M. rosacea*, *M. aurantiaca* and *M. laterita* alongside Eumusa members *M. nagensium* and *M. itinerans*, and with *M. acuminata* to a lesser extent. *Ensete glaucum* was also observed to cohabit with Rhodochlamys members in Mizoram, but the cohabiting of *M. balbisiana* with Rhodochlamys was not found anywhere in north-eastern India.

In north-eastern states, members of both sections, more specifically *M. nagensium*, *M. itinerans* and *M. aurantiaca*, were

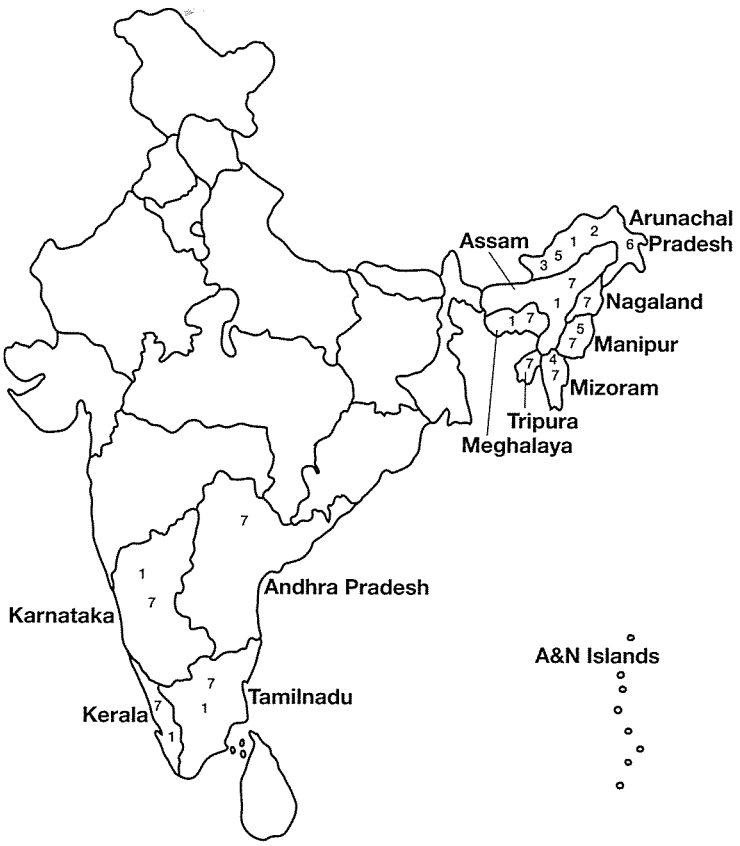

Figure 1. Distribution of *Rhodochlamys* members in India. 1) *Musa laterita* 2) *Musa aurantiaca* 3) *Musa velutina* 4) *Musa rubra* 5) *Musa rosasea* 6) *Musa sanguinea* 7) *Musa ornata.*

seen to hybridize freely and produce intersectional crosses. Some of the hybrids noted by the authors had the Eumusa stature, growing as tall as 2 to 2.5 m, but the main difference was in bunch characteristics. The Rhodochlamys inflorescence was horizontal, while Eumusa members have angular to pendulous bunches and Rhodochlamys members have erect bunches.

One hybrid had 6–8 hands, biseriate fruits (as in Eumusa), bright coloured bracts (as in Rhodochlamys) and ill-filled fruits, even at maturity. This natural hybrid was noticed in the vicinity of *M. nagensium* and *M. itinerans*, but it had rhizomes and suckers arising closer to the mother plant, unlike the rhizomatous roots of *M. itinerans*, where suckers arose 0.5–0.75 m distant to the mother plant. The suckers of this hybrid were brought to NRCB for further detailed studies, including molecular characterization, but they did not survive the trip due to climatic factors. Efforts are underway to re-collect from the same locations.

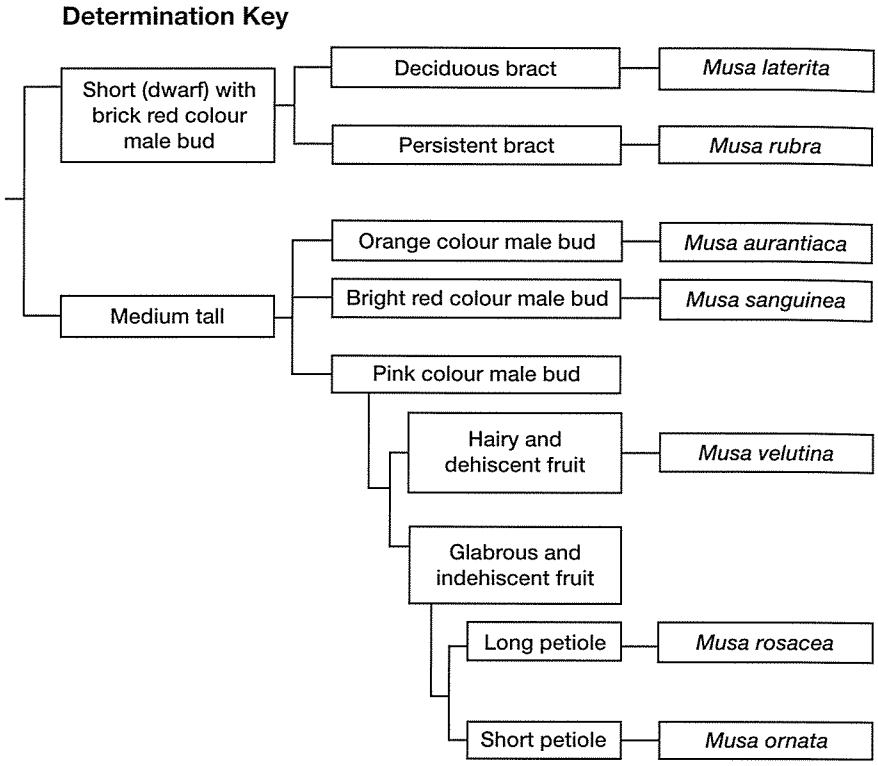

Figure 2. A taxonomic key based on morpho-taxonomic characters for the identification of the members of Rhodochlamys studied in India.

The second type of hybrid exhibited medium stature, slightly tall and more robust than *M. aurantiaca*, with erect inflorescence and bright orange-coloured bracts, but biseriate fruits.

By nature, members of Rhodochlamys exhibit high tolerance to drought through escape mechanisms, and survive long spells of dry weather. At the same time, they exhibit immunity to leaf spot diseases and Fusarium wilt. These are some of the desirable traits for which cultivated bananas need improvement. These traits can be successfully exploited through conventional and non-conventional breeding programmes. At present, most of the genetic transformation techniques rely on isolation of resistant genes from foreign gene pools and their introduction into susceptible landraces. Identification and isolation of such genes from the *Musa* gene pool itself could be more advantageous, and rapid evolution of molecular techniques to isolate genes could aid this. In this context, their genetic relatedness to the section Eumusa, compatibility and source of biotic and abiotic stress-resistance genes could be successfully exploited in breeding programmes for the improvement of cultivated bananas.

M. laterita has an equally high cross-compatibility with *Eumusa* members. Some man-made crosses are available at the Banana Research Station, Kannara, Kerala, India, including H_6, a cross between *M. ornata* and 'Pisang Lilin', with medium-tall stature, erect bunch, weak peduncle giving a bend at the tip, with the rest of the male bud characters similar to *M laterita*. Hence, the correct parentage could be *M. laterita* × Pisang Lilin rather than *M. ornata* × Pisang Lilin, which could be confirmed through molecular characterization.

In another breeding trial conducted at Tamil Nadu Agricultural University, Coimbatore, India, *M. laterita* was crossed (male parent) with ABB culinary types. The resultant generation had tall stature like Eumusa with the profuse suckering roots of Rhodochlamys. In general, compared to other members, *M. laterita* crosses freely with Eumusa and produces intermediary plants (S. Sathiamoorthy, pers. comm.).

In yet another breeding programme, Eumusa × Rhodochlamys crosses were used to introduce precocious suckering in mother plants to yield bigger clumps and more biomass for fibre extraction in a shorter time. Eumusa hybrids (ABB) were crossed with *M. laterita*. The progeny yielded plants with enhanced sucker production capacity, having 8–10 plants (Uma et al. unpublished). The suckers were vigorous and produced double the parent biomass in a span of 6–8 months.

The results suggest that the section Rhodochlamys is not only compatible with Eumusa members, but also a potential source of resistance to biotic and a biotic stresses. So it could very well be exploited both in conventional and molecular breeding programmes to develop synthetic intersectional hybrids.

The occurrence of mutations and intra-hybridization within the same species, as is the case with *M. velutina*, has added more novel types, thus broadening the genetic diversity spectrum for commercial exploitation.

Conclusion

Of 11 species of the section Rhodochlamys described in the literature, only 7 species are found in the Indian subcontinent, namely *M. velutina, M. laterita, M. aurantiaca, M. ornata, M. rubra, M. sanguinea* and *M. rosacea*. They have true natural distribution in the north-eastern states and sub-Himalayan hill ranges. Compared with the Western Ghats of Karnataka and Kerala, Arakku valley of Andhra Pradesh, situated in the Eastern Ghats, harbours *M. ornata* extensively and no other species of the section Rhodochlamys. Though plant lovers maintain some species like *M. laterita* in urban households, their occurrence is seldom seen in natural habitats. This could be due to destruction of the Western Ghat forests, with fast urbanization leading to locational extinction. The Andaman and Nicobar Islands harbour only Eumusa members, no Rhodochlamys.

As a source of biotic and abiotic stress resistance genes, given their genetic relatedness to the section Eumusa and proven compatibility, they could be successfully exploited in breeding programmes for cultivated bananas, and also as good material in marker assisted selection (MAS) programmes.

Due to their inherent beauty, Rhodochlamys members offer enormous scope for commercial exploitation as garden plants. Due to the extensive *jhum* (shifting cultivation) prevalent in north-eastern India and continuing deforestation, *Musa* species in the natural habitats are liable to become extinct. Hence, there is an urgent need for systematic exploration to collect and conserve the section Rhodochlamys, which has been little studied to date, and to broaden the *Musa* genetic base.

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