Annals of Plant Sciences 7.6 (2018) pp. 2342-2346

ANNALS OF PLANT SCIENCES
ISSN: 2287-688X
OPEN ACCESS
www.annalsofplantsciences.com

Research Article

Species diversity and distribution of *Musa* species (Musaceae) in Arunachal Pradesh, North Eastern India.

Gurumayum Ranibala[1], Sorokhaibam Sureshkumar Singh[1*]and Mohammed Latif Khan[2]

[1]Department of Forestry, North Eastern Regional Institute of Science and Technology (Deemed University), Nirjuli-791 109 (Itanagar), Arunachal Pradesh, India.

[2]Department of Botany, Harisingh Gour Vishwavidyalaya, Sagar-470003, Madhya Pradesh, India.

Received: 18-05-2018; **Accepted:** 28-05-2018

Abstract: A long term study conducted from 2011 to 2018 in the Western, Central and Eastern parts of Arunachal Pradesh, North Eastern India revealed occurrence of high diversity of wild *Musa* species (Musaceae) under the sections, *Eumusa* and *Rhodochlamys*. A total of 20 *Musa* specimens consisting of six species under section *Eumusa* and 14 specimens (7 species, 4 unidentified species and 3 hybrids) of *Rhodochlamys* were recorded in the study. *M. cheesmani* among *Eumusa* while *M. velutina* and *M. aurantiaca* among *Rhodochlamys* were most abundant species. All the species and hybrids of *Rhodochlamys* were found growing in disturbed habitats such as degraded foot hills, drying swamps, landslide prone areas and along sides of expanding highway roads. One of the species, *M. rubinea* is at high risk of loss from the natural habitats if proper conservation measures are taken up immediately. In this study, it was observed that collection and identification of the *Musa* specimens were easier based on the traditional sectional classification. It is suggested that that molecular taxonomy using ITS sequences and chloroplast gene loci may improve correct identification of *Musa*, particularly unidentified species and hybrids in the section *Rhodochlamys*.

Keywords: Arunachal Pradesh, diversity, *Eumusa, Musa rubinea*, Musaceae, *Rhodochlamys*

Introduction

Bananas are monocotyledonous plants belonging to the family Musaceae under the order Zingiberales. These plants are reported to be originated from South East Asia and then introduced in other continents (Daniells *et al.,* 2001; Simmonds, 1966). The genus *Musa* was first described by Baker (1893) which was later on revised and divided into 4 sections (*Eumusa, Rhodochlamys*, *Callimusa* and *Australimusa*) based on the number of chromosome present in haploid genome (Cheesman 1947; Simmonds & Shepherd 1955). One more section, *Ingentimusa* represented by a single species was added by Argent (1976). Based on molecular characterization of the internal transcribed spacer (ITS) region of ribosomal RNA (rRNA) gene cluster and several chloroplast gene loci, the intersectional taxonomy of *Musa* has been revised into only two sections (i) sect. *Musa* by combining all members of sect. *Eumusa* and *Rhodochlamys* and (ii) sect. *Callimusa* by merging the members of the three sections *Australimusa, Callimusa* and *Ingentimusa* (Hakkinen, 2013). However, this revision of *Musa* sections has been suggested to be confusing since the genus name and the section names are same i.e. "*Musa*" and preferred the old system of sectional classifications (Christelova *et al.,* 2017). We also followed the old sectional taxonomy of *Musa* in this study.

There are about 70 described species under all the five sections of the genus *Musa* distributed across the world while maximum species were reported from the South East Asian countries which includes North Eastern Region of India (Hakkinen, 2013; PROMUSA, 2018). Recent studies during the last six years have reported seven new species from the region particularly from the state of Arunachal Pradesh increasing total number of *Musa* species to 82 in 2017. Six of the newly described species of *Musa* (*M. argentii, M. arunachalensis*, *M. markkui, M. markuana, M. kamengnensis*, *M. puspanjalieae*) are from Arunachal Pradesh and one species, *M. nagalandiana* has been reported from the state of Nagaland (Dey *et al.,* 2014; Gogoi & Borah, 2013; Gogoi & Borah, 2014; Gogoi & Hakkinen, 2013ab; Hareesh *et al.,* 2017; Sreejith *et al.,* 2013). At present, there are 27 species of wild *Musa* occurring in the region which represents 33% of the total species. Most of the reported species belongs to the sections *Eumusa* and *Rhodochlamys*. In addition to the wild species, a large number of cultivated varieties of *Musa* are found in the traditional home gardens of the region (Molina *et al.,* 2002). These reports have shown that North Eastern Region of the country as one of the important origins of wild banana species. Therefore, the present study aimed to explore and document occurrence of wild banana species from different parts of Arunachal Pradesh.

***Corresponding Author:**
Dr. S. Sureshkumar Singh,
Associate Professor, Department of Forestry
NERIST (Deemed University),
Nirjuli-Arunachal Pradesh-791 109, India.
E-mail: suresh@nerist.ac.in

Materials and Methods

Field survey, sample collection and identification of *Musa* species

Field surveys were conducted in 5 districts of Arunachal Pradesh (Anjaw, Changlang, Lohit, Papum Pare, and West Siang) during the period from 2011 to 2018. Occurrence of banana plants were recorded, samples collected, characterized and documented using the Descriptors for Banana (IPGRI-INIBAP-CIRAD, 1996), Musalogue (Daniells *et al.,* 2001) and personal communication with (Late) M. Hakkinen, Botanic Garden, University of Helsinki, Finland. Herbarium specimens were prepared and deposited in the Herbarium of the Department of Forestry of the institute.

Results

Species diversity of *Musa* (Musaceae) in Arunachal Pradesh

All together 20 specimens (13 species, 4 unidentified species and 3 hybrids) have been collected from five districts representing Western, Central and Eastern areas of Arunachal Pradesh. Six species were members of the section *Eumusa* and the remaining seven species along with unidentified species and hybrids were members of the section *Rhodochlamys*. The list of identified species of *Musa* and their distribution area are given in table 1. Floral and fruit characteristics of selected representatives of *Musa* species under two sections, *Eumusa* and *Rhodochlamys* are shown in figure 1. The *Eumusa* species were *M. balbisiana, M. cheesmani, M. flaviflora, M. itinerans, M. nagensium* and *M. puspanjaliae*. The species of the section *Rhodochlamys* commonly known as ornamental species were *M. argentii*, *M. aurantiaca*, *M. chunii*, *M. mannii*, *M. markkui*, *M. rubinea* and *M. velutina*. Two unidentified *Rhodochlamys* species (Kodum and Koduk) were recorded from Basar area in West Siang only during fruiting stage and no inflorescence were found in the population. One of the specimen (Kodum) appears to be close relative of *M. velutina* in terms of pinkish red coloured fruit, peduncle and rachis and erect inflorescence but differs in dark pink coloured fruit fingers, longer fruit size and hairless fruit skin. The other specimen (Kodok) was found only with fruits but without inflorescence at the time of collection. The pseudostem was slightly taller than average pseudostem of *Rhodochlamys* species (1.5m). The peduncle, rachis and fruits are green which are similar to the characters of *M. laterita* and *M. arunachalensis* but the peduncle is slightly bending like serpentine, size of the rachis is significantly large and short and very few numbers of fertile fruits were present. The third unidentified specimen was collected also in fruiting stage only from the Hayuliang road (between Paya and Mekiliang). The peduncle, rachis and fruit are green, rachis is curved in the middle, fruit hands are very long as compared to other *Rhodochlamys* members, mature fruit is sweet and soft pulp with few seeds, male inflorescence was aborted. The fourth unidentified species was recorded on the roadside of Ziro road between Kimin model village and Potin of Paumpare district. The inflorescence and bract colour were closely similar to *M. markkui* but the mature fruits were reddish brown colour on outer skin which is very closely similar to the fruits of *M. flaviflora*.

Table 1. List and distribution of wild *Musa* species in Arunachal Pradesh

S. No.	*Musa* species from Arunachal Pradesh (Local name)	Distribution area	Section
1	*Musa balbisiana* (Bhim kol)	Nirjuli, Doimukh,, Ganga (Papum Pare)	*Eumusa*
2	*M. cheesmani* (Kuhi kulu)	All Areas	
3	*M. flaviflora* (Kas kol)	Nirjuli (Papum Pare)	
4	*M. itinerans* (Langak)	Miao, Diyun (Changlang)	
5	*M. nagensium* (Dup kulu)	Miao (Changlang), Hayuliang (Anjaw)	
6	*M. puspanjaliae* (Dura kulu)	Salangam (Lohit), Ziro	
7	*M .argentii*	Diyun (Changlang)	
8	*M. aurantiaca* (Kodok)	Miao (Changlang), Basar (West Siang)	
9	*M. chunii*	Miao, Diyun (Changlang), Salangam (Lohit)	
10	*M. mannii* (Miao kulu)	Miao, Diyun (Changlang)	
11	*M. markkui*	Hayuliang (Anjaw)	
12	*M. rubinea*[#]	Namsai (Lohit)	
13	*M. velutina*	Nirjuli (Papum Pare), Miao (Changlang), Basar (West Siang)	*Rhodochlamys*
14	*Musa* hybrid 1	Hayuliang road (Anjaw)	
15	*Musa* hybrid 2	Hayuliang road (Anjaw)	
16	*Musa* hybrid 3 (Sera kulu)	Diyun (Changlang)	
17	Unidentified species 1	Ziro (Lower Subansiri)	
18	Unidentified species 2 (Koduk)	Basar (West Siang)	
19	Unidentified species 3	Hayuliang road (Anjaw)	
20	Unidentified species 4 (Kodum)	Basar (West Siang)	
Total :13 species+4 unidentified species+3 hybrids			

[#]*Musa rubinea* is reported for first time in this study from India.

Figure 1(a-l). Floral and fruit characters of representative *Musa* species from Arunachal Pradesh. *Eumusa: Musa cheesmani* (a & b), *M. itinerans* (c & d), *M. nagensium* (e & f) and *M. puspanjaliae* (g & h); *Rhodochlamys*: *M. markkui* (i), *M. chunii* (j), *M. mannii* (k) and *Musa* hybrid 2 (l).

Two of the unidentified hybrids of *Rhodochlamys* (Hybrid 1 & 2) were found along the roadsides of Hayuliang road (between Paya and Mekiliang) in Anjaw district (Fig. 1). The *Musa* hybrid 1 was similar to the characters of *M. rubinea* in opening or lifting of many bracts at a time but differs in presence of green coloured peduncle and rachis which are reddish coloured in *M. rubinea*. The colour of bract is pale rose in this hybrid but ruby red coloured in *M. rubinea*. The *Musa* hybrid 2 was closely similar to that of *M. markkui* in having rose-pink bract colour but the *Musa* hybrid 2 differs in presence of persistent male bud and fruit fingers pointing perpendicular to the axis as well as the fruit bunch hanging horizontally from the peduncle at maturity. The *Musa* hybrid 3 (Sera Kulu) appears to be a hybrid of *M. velutina* and *M. chunii* since the peduncle, rachis and fruits are pink coloured similar to the characters of *M. velutina* while colour of bract is violet on outer as observed in *M. chunii*.

Distribution of *Musa* species in Arunachal Pradesh

M. balbisiana was recorded from Nirjuli village and other parts of of Papum Pare district. *M. flaviflora* was found in two areas within Nirjuli village. *M. puspanjaliae* was recorded from a hillock in Ziro area of Lower Subansiri district and also from roadside hills on the Hayuliang road of Anjaw district. *M. nagensium* was recorded from Hayuliang area of Anjaw district and Miao village of Changlang district. *M.cheesmanii* was most abundant and widely distributed among *Eumusa* species recorded in the present study.

Among the members of *Rhodochlamys*, *M. aurantiaca* was recorded from Miao area of Changlang district and Basar area of West Siang district. *M. chunni* was recorded from Miao and Diyun area of Changlang district and Salangam area of Anjaw district. *M.mannii* along with *M. rubinea* were recorded from Chowkham areas of Lohit district and Diyun area in Changlang district. *M. veutina* was

found to be distributed in most of the study sites (Papum Pare, Lohit, Changlang and West Siang districts). All the species and hybrids of *Rhodochlamys* were found to grow in peripheral areas and disturbed habitats such as degraded foot hills, drying swamps, landslide prone areas and along sides of highway roads.

Discussion

The present study recorded a total of 20 banana specimens comprising of 6 species of *Eumusa* and 7 species along with 4 unidentified species and 4 hybrids under the section *Rhodochlamys*. The members of the section *Eumusa* are large plants whose pseudostem reach a height of 3 to 7m. Most of the species under the genus *Musa* and edible and cultivated banana varieties are believed to be produced by natural hybrids of two parents, *M. balbisiana* (Bhimkol) and *M. acuminata* (Hakkinen & Vare, 2008; Robinson & Sauco, 2010; Simmonds & Shepherd, 1955). The species, *M. balbisiana* has been reported to occur in all states in North Eastern India particularly in Assam (Subbaraya, 2006). Because of abundance of diverse species of wild *Musa* in the state we had a strong expectation to find wild species of *M. acuminata* in Arunachal Pradesh but we could not find the species in the study areas. Previous studies have also revealed less prevalence of the wild *M. acuminata* species in the state although presence of wild species was reported to occur in the wild habitats of the state (Choudhury *et al.,* 2009; Subbaraya, 2006; Uma *et al.,* 2001). *M. cheesmani* was most abundant and widely distributed species found in all areas of study.

The members of *Rhodochlamys* are small plants bearing important morphological features such as bright coloured bracts and fruits (red, violet, pink, purple and orange to golden colours) which make them ornamentally attractive for floriculture uses. The present study recorded a total of 14 specimens under this section which proves that the state is a rich natural heritage of this diverse banana plants, especially the ornamental *Musa* species of the section *Rhodochlamys*. The occurrence of diverse species of ornamental banana has been reported from the region by many workers (Gogoi *et al.,* 2017; Hakkinen, 2005; Hakkinen *et al.,* 2002; Joe & Sabu, 2016; Subbaraya, 2006). A detailed review and analysis of the published literature revealed that there are 18 species of ornamental bananas in the world of which 14 species (78%) are found in the North Eastern region while 12 species (67%) are found only in the state of Arunachal Pradesh. The occurrence of *M. rubinea* reported in this study is first record of the species from the state and the country.

One of the important issues in the identification of ornamental banana based on morphological character was close similarities of some species and the hybrids in addition to unavailability of floral parts during the field study periods. Therefore, repeated visits to observe and collect floral parts of the specimens where floral parts were not collected in previous visits may be done for proper identification of species. Additionally, it is suggested that use of molecular tools like internal transcribed spacer (ITS) region of the ribosomal RNA (rRNA) genes from nuclear DNA and potential barcode loci of chloroplast DNA (*rbc*L, *mat*K, etc.) may be employed to strengthen identification of the ambiguous specimens.

The wild habitats of the *Musa* species belonging to *Rhodochlamys* were under tremendous stress of natural and manmade causes like increasing degradation of swamps and wetlands, expanding agricultural activities, road and communication infrastructures development activities, fragile foot hills prone to landslide, etc. This suggests that there is an urgent need for a state level conservation strategy of these ornamental banana species in a sustainable manner before their extinction in the near future. For instance, we have recorded only one plant of *M. rubinea* in flowering stage from a location between Chowkham and Medo area of Lohit district along the state highway road which is rapidly expanding at present. Therefore, it is highly possible that the species may be lost from the area if immediate action is not taken up for conservation and protection.

Conclusions

A long term field survey and exploration studies revealed occurrence of high diversity of *Musa* species in Arunachal Pradesh. Comparatively, number of species and specimens collected were higher in the section *Rhodochlamys* as compared to *Eumusa*. There was more complexity in identification of *Rhodochlamys* species based on morphological characters. Majority of the diverse species of *Musa* were concentrated toward Central and Eastern parts of Arunachal Pradesh though Western parts also displayed presence of *Musa* species. In this study, it was observed that collection and identification of the *Musa* specimens were easier and convenient based on the traditional sectional classification. It is suggested that molecular taxonomy using ITS sequences and chloroplast gene loci may improve correct identification of *Musa*, particularly unidentified species and hybrids in the section *Rhodochlamys*.

Acknowledgement

Authors gratefully acknowledge financial assistance and computational facility of Bioinformatics Infrastructure facility (BIF) sponsored by DBT, Govt. of India, New Delhi. Authors are also thankful to Mr. S. Suranjit Singh, AE, PWD, Anjaw district, Govt. of Arunachal Pradesh, Mr. T. Yomcha, Research Officer, Namdapha National

Park, Mr. P. Shivadutta Singh and Mr. Roshan Chongtham for their help during field survey and sample collection.

References

1. Argent GCG. The wild bananas of Papua New Guinea. *Notes Royal Bot. Garde. Edinb.* 35 (1976): 77-144.

2. Baker JG. A synopsis of genera and species of Musaceae. *Annals of Botany* 7(1893): 189-229.

3. Cheesman EE. Classification of Bananans. *Kew Bull.* 2 (1947): 106-117.

4. Chowdhery H J, GS Giri, GD Pal, A Pramanik, and S K Das. . Materials for the flora of Arunachal Pradesh, Volume 3 ed. H. J. Chowdhery, G. S. Giri and A. Pramanik), BSI, India, (2000) pp. 184.

5. Daniells J, C Jenny, D Karamura and K Tomekpe. Musalogue: A catalogue of Musa germplasm. Diversity in the genus *Musa* (E. Arnaud & S. Sharrock, Edrs. INIBAP), Montpelier, France, (2001) pp. 213.

6. Dey S, NS Jamir, R Gogoi, SK Chaturvedi, HY Jakha and ZP Kikon. *Musa nagalandiana* sp. nov. Musaceae) from Nagaland, northeast India. *Nord. Journ. Bot.* 32 (2014): 584-588.

7. Gogoi R and S Borah. *Musa markkui* (Musaceae), a new species from Arunachal Pradesh, India. *Gard. Bull. Singapore* 65 (2013): 19-26.

8. Gogoi R and S Borah. *Musa argentii* (Musaceae), a news species from Arunachal Pradesh, India. *Edin. Journ. Bot.* 71 (2014): 181 – 188.

9. Gogoi R and M Hakkinen. *Musa puspanjaliae* sp. nov. (Musaceae) from Arunachal Pradesh,India. *Nord. Journ. Bot.* 31 (2013a): 473–477.

10. Gogoi R and M Hakkinen. *Musa kamengensis* (Musaceae), a New Species from Arunachal Pradesh, India. *Acta Phytotax. Geobot* 64 (2013b): 149–153.

11. Gogoi R, S Borah and M Hakkinen. Diversity of wild bananas (*Musa* L.-Musaceae) in the state of Assam, India. In *compendium of botanical research in Eastern India* (ed. Medhi, P and Roy, H), EBH Publishers, India, (2017) pp. 81-98.

12. Hakkinen M and S Sharrock. Diversity in the Genus *Musa*- Focus on *Rhodochlamys*. INIBAP, annual report 2001.INIBAP, Montpellier, France, (2002) pp. 16-23.

13. Hakkinen M. Ornamental bananas- Focus on the section *Rhodochlamys*. Bulletin *Helic. Soc. Inter.* **12** (2005): 1-7.

14. Hakkinen M. Reappraisal of sectional taxonomy in *Musa* (Musaceae). *Taxon* 62 (2013): 809-813.

15. Hareesh VS, A Joe, PE Sreejith and M Sabu. *Musa markkuana* stat. nov. (Musaceae)- A reassessment of *Musa velutina* subsp. *markkuana*. *Phytotaxa* 303 (2017): 279-284.

16. IPGRI- INIBAP-CIRAD. Descriptors for Banana (*Musa* spp.), (199)6 pp. 55. (https://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-banana-musa-spp/).

17. Joe A and M Sabu. Wild ornamental bananas in India: an overview. *South Indian Jourl. Biol. Sc.* **2** (2016): 213-221.

18. Molina AB and C Kudagamage. The international network for the improvement of banana and plantain (INIBAP): PGR activities in south Asia. In: South Asia Net-work on Plant Genetic Resources (SANPGR) meeting held on December 9-11 at Plant Genetic Resources Center (PGRC), Peradeniya, Sri Lanka, (2002) pp. 1-7.

19. PROMUSA (http://www.promusa.org/Wild+species+portal, accessed on 10th May (2018)

20. Simmonds NW and K Shepherd. The taxonomy and origin of the cultivated Bananas. *Jour. Linn. Soc.* 55 (1955): 302-312.

21. Simmonds NW. Bananas. 2nd Ed. Trop. Agr. Series, Longman, NY (1966).

22. Sreejith PE, A Joe, and M Sabu. *Musa arunachalensis*: a new species of Musa section *Rhodochlamys* (Musaceae) from Arunachal Pradesh, northeastern India. *Phytotaxa* 134 (2013): 49–54.

23. Subbaraya U. Farmers Knowledge of Wild *Musa* in India, FAO, Rome, (200)6 pp. 46.

Cite this article as:

Gurumayum Ranibala, Sorokhaibam Sureshkumar Singh and Mohamed Latif Khan. Species diversity and distribution of *Musa* species (Musaceae) in Arunachal Pradesh, North Eastern India. *Annals of Plant Sciences 7.6 (2018) pp. 2342-2346.*

http://dx.doi.org/10.21746/aps.2018.7.6.7

Source of support: DBT, Govt. of India, New Delhi, India.
Conflict of interest: Nil