

AGRO-ECOLOGIES IN THE AREAS OF EXISTING WILD *MUSA*

Wild *Musa* species are largely distributed in some tropical rain forests, wet evergreen forests to deciduous forests of low rainfall zones. The hilly tracts of these areas harbour a mosaic of tropical forests where *Musa* species may occur (Figure 1).

Tropical rain forests are found in the northeastern Indian Himalayas including Assam, Arunachal Pradesh, Meghalaya, parts of Nagaland to the southeast of India proper, and also in the Andaman and Nicobar Islands. Some tropical forests still exist in Manipur, Mizoram, Tripura of northeastern states, and in interior areas of western Ghats of Karnataka and Kerala (Rao, 1996; Rao,

1999). The few remaining forests are disturbed by the incursion of humans.

These ecological zones are characterized by wide climatic variation ranging from tropical, and subtropical, temperate to alpine zones. The temperature ranges from 8-15°C (mean minimum) to 30-35°C (mean maximum) and average annual temperature is between 18 and 22°C. March to April are the hottest months while November-January are the cold months. Rainfall is well distributed throughout the year except for February-April. Tropical rain forests receive rainfall in the range of 3 200-3 800 mm per year and Chirapunji of Meghalaya state receives one of the world's highest annual rainfalls.

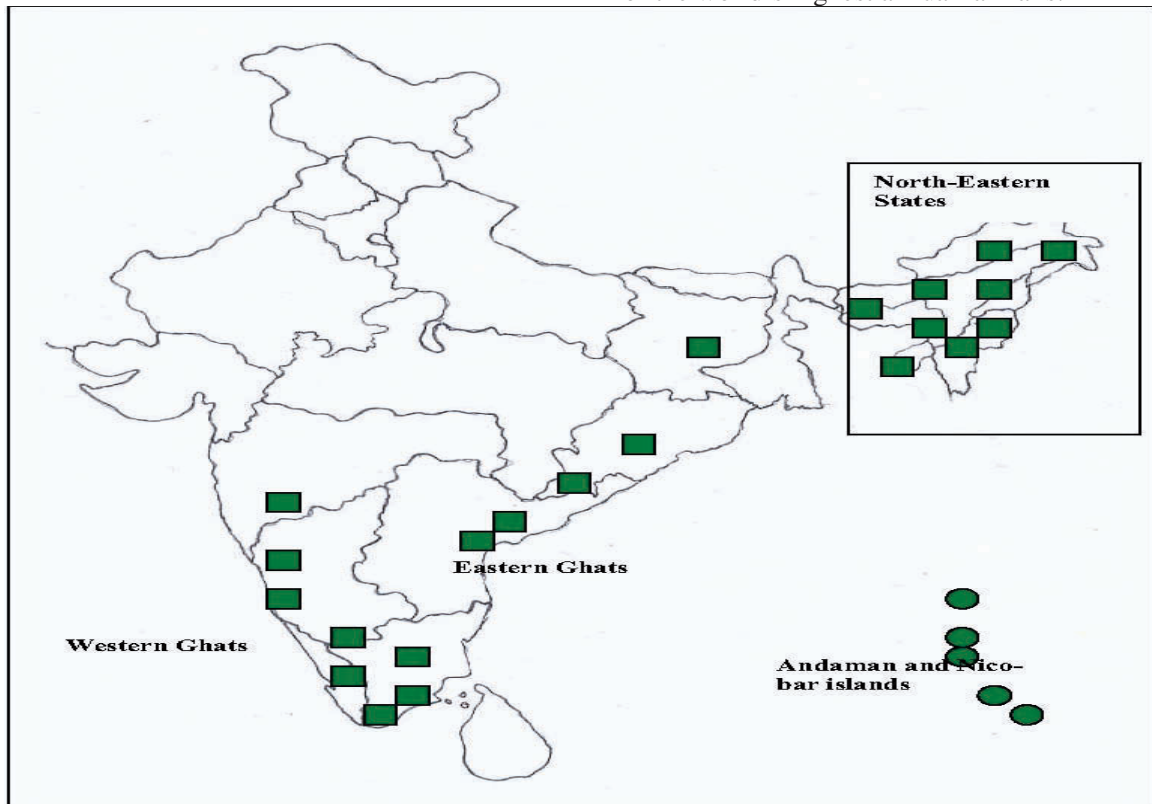


Figure 1. Areas of India where wild *Musa* occurs

Table 1. Details of exploration zones

States	Localities or locations	Number of villages or groups consulted (Approximate)	Ethnic groups or tribes
Arunachal Pradesh	Tawang, West Kemeng, East Kemeng, Lower Subansiri, Lohit-	Villages > 50 Groups > 50	Nitshi, Apatani, Sherdukpens, Adi Aka, Monpa, Mishmi
Meghalaya	Jowai, Nongpoh, Shillong	Villages > 15 Groups > 18	Garo, Khasi, and Jaintia
Assam	Kamrup, Kochbihar, Kokrajar, Nalbari, Dibrugarh, Tezpur, Kaziranga reserve forest	Villages > 32 Groups > 30	Koch, Bodo, Hajong, Aitunia, Karbi and Ahom
Tripura	Agartala, Ambassa, Udaipur, Dhrmanagar	Villages > 22 Groups > 20	Reangs, Chakmas, Meksha and Raichak
Mizoram	Aizawl, Kolasib, Ssairang, Seling	Villages > 20 Groups > 20	Luushai, Pawi, and Pang
Manipur	Imphal, Thamenglong, Noney, Ukhrul, Senapati	Villages > 30 Groups > 25	Manipuri, Kabui, Maram Meiteis, Thado and Ao
Nagaland	Dimapur, Kohima, Mao Song Sang	Villages > 25 Groups > 20	Naga, Sema, Angami, Ao, Mon, Lotha and Chakesang
Karnataka	Mysore, Coorg, Dharwar, Sirsi, Koraga, Kuruba, Sholiga	Villages > 35 Groups > 25	Jenu Kuruba, Bedar, Naika, Koraga, Kuruba, Sholiga
Tamil Nadu	Shevoroy hills, Pechipparai, Kanya kumari, Tirunelveli, Gudalur, Nilgiri Hills	Villages > 50 Groups > 28	Toda, Kattu Naikar, Korava, Malayali, Mudugar
Kerala	Silent Valley, Munar forest, KMTR reserve forest,	Villages > 25 Groups > 20	Irulas, Mylar, Malayalan, Mudugar
Andhra Pradesh	Arakku Valley, Tirumala Hills, Rajamundry, Vishakapatnam	Villages > 10 Groups > 10	Bhil, Chenchu, Gondu, Banjara
Andaman and Nicobar Islands	PortBlair, Chouldhari reserve forest, Rut Island, Bamboo Flat Island, Manglutan, Havelock Island, Ross Island	Villages > 30 Groups > 30	Andamanese, Bo, Shompen, Nicobarese, Sintelenese

Tropical moist forests receive an annual rainfall of 1 200-1 600mm. Southwest monsoon accounts for the maximum rain in the northeastern states, western Ghats and Andaman and Nicobar Islands from April-August. Depressions during November-December and the southwest monsoon make up the annual rainfall in eastern Ghats and Andaman and Nicobar Islands. Relative humidity is usually high ranging between 82 and 85 percent.

Domesticated banana is basically a tropical crop but can grow in the warmer parts of subtropical regions. Of their progenitors, *Musa acuminata* is more tropical, but some subspecies of it can also be found at the edges

of the subtropics or in tropical highlands. *Musa balbisiana* can be found farther north and in areas with strong dry seasons. In India, the remaining wild species occur at an altitude between 500-1 000 m above sea level in the sub-Himalayan mountains and western Ghats (Figure 2). In northeastern India in Khasi, Jaintia, Naga, Patkai and Garo hills, wild *Musa* species may occur also at both lower and higher altitudes. In the western Ghats, two centres of diversity, namely Agasthiarmalai and Silent Valley, are under moist tropical evergreen forests where evolution of *Musa* species has taken place separately from the northeastern zone.

Table 2. Types of questionnaires used during the surveys and exploration process

Type of questionnaire	Questionnaire A	Questionnaire B	Questionnaire C
Target group and topics of questionnaire	For individuals or individual families	For village communities – General Information	<i>For village community – on improved varieties</i>
Information requested	<ol style="list-style-type: none"> 1. Name and family details 2. Land holding (backyard; community land or Jhum cultivation) 3. If backyard: types of fruit plants maintained 4. If bananas are grown: <ul style="list-style-type: none"> ▪ varieties grown; ▪ number of clumps maintained per variety; ▪ nature of cultivation (perennial or rationing); ▪ cultivation practices; ▪ disposal of bunches (consumed or sold to village market or sold to contractors); ▪ importance of bananas and plantains in their diet; ▪ other uses of the plant like flower buds, pseudostem core, etc., ▪ indigenous technical knowledge (ITK). 	<ul style="list-style-type: none"> - Village holding and types of tribal communities - Distribution of tribal communities - Types of vegetation and prevailing farming systems - Composition of surrounding vegetation - Extent of spread of wild <i>Musa</i> - Types of wild <i>Musa</i> in their area - Distribution pattern of wild <i>Musa</i> - Intensity of spread of wild <i>Musa</i> species - Climatic conditions of the location (temperature, rain fall, length of winter period, number of rainy days) - Occurrence of natural calamities (drought, floods, frost and frequencies of occurrence) - Utility of wild species - Extent and mode of commercial exploitation, if any - Important traits noticed for the wild <i>Musa</i>, like better fibre content, sweet pulp, enhanced ash/dry matter content of plant parts - Distinct traits of wild species like rhizomaous roots or erect bunch or seedy fruits - Observation on the wild spp. About their adaptations to abiotic stresses like drought, high/low temperature - Natural conservation of wild species - Community efforts to conserve wild <i>Musa</i> species, if any - ITK of wild species - Validity of proof, if any on ITK 	<ul style="list-style-type: none"> - Number of domesticated <i>Musa</i> varieties - Time since they have been cultivated - If there is a new introduction, source and mode of introduction - Reasons for cultivating a new variety - Socio-economic reasons for introduction of new varieties - Marketing channels for commercial varieties - Method of multiplication of commercial varieties – suck bits or peppers, seeds - Mode of exchange of material - Mode of conservation, season and duration of conservation - Conventional value added products, if any



Figure 2. Natural habitats of wild *Ensete superbum* in western Ghats

The Andaman and Nicobar Islands (Figures 3 and 4), consisting of 350 islands and islets, lie in the Bay of Bengal (latitude 6°14'N and longitude of 92-94° E). Within a land area of 8 500 km², endemic flora has evolved over millions of years due to insular nature and physical isolation among islands and also from neighbouring continental land masses. The major islands are: North Andaman, Middle Andaman, South Andaman, Little Andaman, Car Nicobar, Teressa, Katchal, Kamorta, Noncowry, Little Nicobar and Great Nicobar.



Figure 3. Natural habitats of wild *Musa* spp. in Andaman Islands

Eastern Ghat forests are located along the coastal line of the Bay of Bengal. Originally they extended from northern Orissa down to Andhra Pradesh. However, due to rapid deforestation in this zone, hardly any forests exist except for some pockets of northern Andhra Pradesh in Arakku Valley and southern Orissa where wild *Musa* species are known to occur. They are low hills with an altitude of 300-400 m above sea level, annual rainfall ranging from 900-1 300 mm and RH of 78-80 percent. The occurrence of *Musa* species in different geographical locations in India is illustrated in Annex 1 whilst the genetic diversity of wild bananas is shown in Figures 5 to 15.



Figure 4. Natural habitats of wild *Musa* spp. in Nicobar Islands

GENETIC DIVERSITY OF WILD BANANAS



Figure 5. *Musa sanguinea*

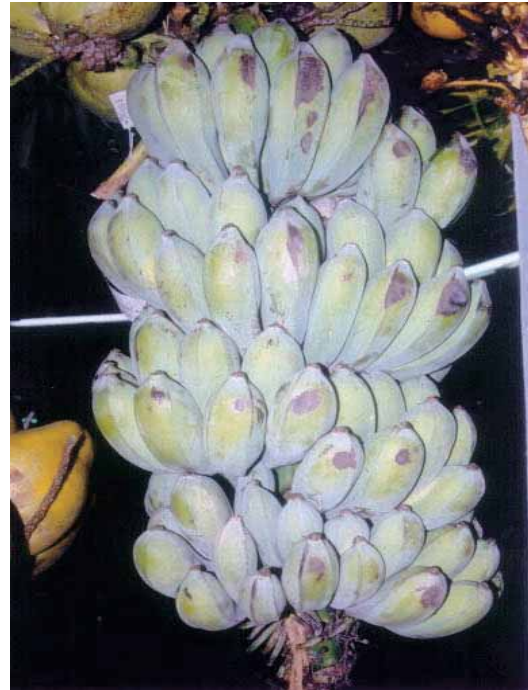


Figure 6. *Musa balbisiana* var. *Andamanica*



Figure 7. *Musa rosaceae*



Figure 8. *Musa balbisiana*



Figure 9. *Ensete glaucum*



Figure 10. *Musa itinerans*



Figure 11. *Musa rosaceae*



Figure 12. Buds of several wild and semi-wild species at different stages



Figure 13. Fruits and seeds of *Ensete glaucum*



Figure 14. Fruits and seeds of *Ensete* spp.



Figure 15. Fruits and seeds of wild *Musa* spp.

MUSA AND ITS EVOLUTION

Bananas belong to the family *Musaceae*, in the order Zingiberales. The family *Musaceae* has two genera, *Musa* and *Ensete*, of which *Musa* encompasses wild and domesticated bananas and plantains. *Musa* has been subdivided into five sections, *Callimusa*, *Australimusa*, *Eumusa*, *Rhodochlamys* and *Incertae sedis* (Daniells, *et al.*, 2001). The genus *Ensete* is present in Africa and Asia, and is considered an old and relict genus with few good species.

[Editor's note: The reader is referred to Simmonds' classical book "The Evolution of the Bananas" published in 1962 for a succinct overview of banana evolution. Most of that treatment still stands, but three recent papers by Wong, *et al.* question the separateness of the sections. In these papers they combine *Musa* (*Eumusa*) with *Rhodochlamys* and *Callimusa* with *Australimusa*. It remains to be seen if these combinations will stand the test of more extensive research and time. In any case, the old section *Callimusa* contains small-statured ornamental bananas, *Rhodochlamys* also contains ornamental bananas, *Australimusa* contains the fibre bananas, *Musa textilis*, and the Pacific domesticates called 'Fe'i' bananas. The old section *Eumusa* contains the abundance of domesticated bananas and their progenitor wild species, as well as others.]

Domesticated bananas are parthenocarpic and generally seedless. Nearly all existing varieties were domesticated in prehistory by villagers of India through to New Guinea. Seeded *Musa acuminata* (Genome AA) became the progenitor of parthenocarpic AA diploid clones and of AAA triploids. The great bananas of international commerce (Cavendish) is an AAA triploid derived from pure *Musa acuminata*. The main area of domestication of pure *acuminata* types was probably Malaya and neighbouring islands and areas as far east as the Indo-Chinese peninsula.

The majority of domesticated clones, however, are of hybrid origin between *Musa acuminata* and the other major wild species in *Eumusa*, *Musa balbisiana* (Genome BB). They are either AB, AAB, or ABB in genomic terms.

The key mutation required to convert wild banana fruit into readily consumable fruit was parthenocarpy. This trait is governed by one or a few genes and it enables the fruit to fill with pulp even in the absence of pollination. This is different from seedlessness, which is governed by other genes, or induced by triploidization. Parthenocarpy must have occurred many times in *Musa acuminata* in Malaya and surrounding areas, enabling local people to pick up and grow different types which gradually became less seedy as other mutations occurred for seedlessness or as triploids occurred naturally.

[Editor's note: For *Musa balbisiana*, the situation was different. Pure parthenocarpy either did not occur, or it was not picked up. Although Simmonds shows this species ranging from Sri Lanka and southeast India through to northeast India, Myanmar, South China to the Philippines and New Guinea, it is still not clear in how much of this area truly wild *Musa balbisiana* was and is native. In ancient times suckers of this species must have been carried far and wide as people migrated away from areas where it was native since it was and still is used today as a favourite leaf-banana. Its leaves are hardly affected by leaf spots and are favoured and sold for wrapping food and for plates. Thus, this other species was, in effect, domesticated, and, being highly male fertile, and at first, female fertile, hybridization occurred readily with the fruit-favoured parthenocarpic *acuminatas* in the villages. With time, these "domesticated" balbisianas were selected for soft-seeds and for fewer seeds and now these types are largely sterile, are given names and propagated by suckers. In this paper, the author treats

these as a wild species, whereas, in fact, they are domesticated, soft-seeded clones. In any case, it is not known how much of the hybrid A and B clones resulted from domesticated *acuminatas* being moved into areas where native wild *balbisiana* was present or how much was due to *balbisiana* clones being moved into *acuminata*-containing villages.]

India contains the largest number of hybrid AB clones of all types. It is reasonable to believe that most AABs and ABBs were from India and nearby areas such as Myanmar, Sri Lanka and Thailand. In India, it is well accepted that India is a major centre of

domesticated banana origin and domestication (Singh and Suryanarayana, 1997; Jogiraju, 1931; Jacob, 1942a; Venkataramani, 1949; Chakravorti, 1948b; Chandraratna, 1951; Gandhi, 1952; Dutta, 1952; Nayar, 1952, 1958; Singh, *et al.*, 1998; Uma and Selvarajan, 2001).

[Editor's note: It is believed by many that *Musa balbisiana* is truly wild in parts of the Philippines where there is some diversity and good seed viability and that this area was another site of hybrid AB domestication.]

WILD *MUSA* SPECIES IN INDIA

The major concentrations of wild species remaining in India is in the far northeastern states abutting China and Myanmar on the north and east and Bangladesh to the west.

In the southeastern and western Ghats there was formerly much forest, now mostly gone. With the disappearance of forest there is a disappearance of wild bananas. Sparse remnants remain at a few sites.

[Editor's note: Much more field work and taxonomic work will be required to elucidate what species still exist in the wild in different parts of India.]

SECTION EUMUSA

Among the five major sections, Eumusa has at least 11 species and most of the edible bananas. *Musa acuminata* and *Musa balbisiana* in this section are the progenitors of most of the edible bananas.



Figure 16. *Musa nagensium* with elegant black pseudostem

Of the possibly 11-12 existing species of Eumusa, India has possibly seven: *Musa acuminata*, *Musa balbisiana*, *Musa itinerans*, *Musa nagensium*, *Musa aurantiaca*, and,

possibly, *Musa sikkimensis* and *Musa cheesmani*. These last two were reported by Simmonds (1962) as well as an eighth species, *Musa flaviflora*, all from Assam.

Musa itinerans, a unique species with spreading rhizomatous roots, is distributed in Manipur (Simmonds, 1962), Mizoram and Arunachal Pradesh (Uma, *et al.*, 2003b). *Musa nagensium* (Figure 16) has been recorded in all northeastern states, Meghalaya, Manipur and Arunachal Pradesh, and it forms an exclusive underflora in the moist evergreen forests. In Arunachal Pradesh forests, *Musa nagensium* stretches over several hundreds of acres monotonously while *Musa aurantiaca* also occurs (Figure 17).



Figure 17. Natural clump of *Musa aurantiaca*

At least ten subspecies of *Musa acuminata* have been named and others probably exist. The Indonesian islands still having forests contain most subspecies and an abundance of wild plants. The remaining forests of Indochina, Malaysia and the Philippines and New Guinea also contain much *acuminata*.

In India, *Musa acuminata* has been identified in the natural habitats of Kaziranga forest

range of Assam, Khasi hill ranges of Meghalaya, southern and middle Andamans and in western Ghats of Karnataka. Surprisingly, Arunachal Pradesh with maximum diversity for other *Musa* species harbours less *Musa acuminata*. Morphotaxonomic and molecular characterization of these wild types revealed their identity to be *banksii*, *burmannica* and *burmannicoides*, suggesting that India has only three subspecies of *acuminata*.

[Editor's note: The mention of *Musa banksii* as present in India has to be in error as this subspecies is centred in New Guinea and not known west of Sulawesi. Also, whether *Musa burmannica* and *burmannicoides* are really different subspecies is questioned by such authorities as Shepherd.]

DIVERSITY OF *MUSA BALBISIANA*

The "B" genome from *Musa balbisiana* has been a rich genepool for many genes conferring resistance to various pests and diseases. Due to limited variability, this species has not been separated into subspecies. The wild accessions are simply mentioned as 'types' represented by the area or locality from where they were collected. *Musa balbisiana* is distributed in all the natural habitats of bananas, for example, Tamil Nadu, Kerala, Andhra Pradesh, Karnataka, Bihar, Orissa, West Bengal, northeastern states, and Andaman and Nicobar Islands. When wild forms of *Musa balbisiana* are discussed, it is very important to mention *Bhimkol* and *Elavazhai*, two wild types which have assumed the role of commercial varieties among the Assamese people and folks of western Ghats of Karnataka and Kerala, respectively.

[Editor's note: Whether *Musa balbisiana* is truly wild and indigenous in the states the author lists is probably not established. Since this species has been spread widely by humans in migrations, probably as suckers, it is now, indeed, present widely in villages. Where the clones are largely sterile and with distinctly different characteristics, they are really domesticated clones such as the ones

described below. They are not "wild bananas". Feral *Musa balbisiana* could occur around villages, where introductions have been of fully fertile individuals.]

BHIMKOL

This is the most popular *Musa balbisiana* wild seeded type (BB) which has crept into large scale cultivation in northeastern India. Over years, *Bhimkol* (Figure 18) has been accepted as a household variety and is no more considered as wild. *Bhimkol* has its maximum distribution in Assam and to some extent in neighbouring states like West Bengal, Meghalaya, etc.

Bhimkol surprisingly has no localized cultivation on a stretch of land but each and every Assamese household has a minimum of four to five *Bhimkol* clumps in its backyard and its cultivation is approximately worked out to be on more than 8 000 ha. For a wild variety, this popularity is worth mentioning, which is attributed to several of its good traits mentioned under ethnobotany.



Figure 18. *Bhimkol*

Discussion with people and the available literature gave no specific mention of its era of commercial recognition. It is, however, evident that *Bhimkol* has been grown from time immemorial by Assamese tribes. Complete survey and study of diversity using morphological and molecular characterization has led to the understanding that the diversity among *Bhimkol* is almost nil. This owes to the fact that *Bhimkol* has strong pollination and fertilization barriers and the seed development is always incomplete. The ovules enlarge to become seeds but they are devoid of any endosperm and well developed embryo. Hence they are empty-seeded fruits. This trait of soft seededness makes it acceptable to eat as is pomegranate (*Punica granatum*).

ELVAZHAI

It is a common seeded, diploid, wild type grown in all rural households of western Ghats of Karnataka. The main uses of *Elavazhai* (Figure 19) in daily life is the use of leaves as dining plates, as a part of their culture.

It is also used as a shade crop in areca palm plantations. Mixed cropping with this wild type is found to improve the microclimatic conditions favourable for arecanut. The

leaves are also preferred for cooking special dishes over the leaves of other banana varieties, which are affected with foliar diseases.



Figure 19. *Elavazhai*