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TAXONOMIC SCORING AND GENOMIC GROUPING IN BANANAS

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ABSTRACT

Score techniques in *Musa balbisiana* ranges from 15-75 depending upon the genomic group. Evolution of modern banana is chain neaction of *Musa accuminala* and *Musa babislana.*

Figures : 02 References : 07 Tables : 03

KEY WORDS : Banana, Genomic groupings, Taxonomic scoring.

Introduction

The plant is a gigantic herb basically consist of a pseudostem made up of leaf sheaths with an inflorescence pushing through the sheaths. The banana is a basic staple in tropical countries and was consumed before recorded history in South East Asia. These are basically of two kinds :-

- Plantain [cooking banana – consumed after cooking]
- Banana [dessert banana - consumed mostly as fresh fruit]

These were described as *Musa paradisiaca* and *Musa sapientum* in the early 1700s. The family Musaceae [under the order Scitaminae] is composed of bananas, plantains and ornamental bananas originally evolved in Southeast Asia and surrounding tropical and sub-tropical regions [including New Guinea]. Africa is the secondary centre of diversity.

Ensete and *Musa* are the two genera in this family. *Musa* has four different sections (Table-1) namely Australimusa, Callimusa, Eumusa and Rhodochlamys. *Eumusa* has edible species and hybrids that are now being largely cultivated worldwide[2].

1. Australimusa – *Musa textilis* yields the manila hemp or abaca fibre.
2. Callimusa – *Musa coccinea* is an ornamental species.
3. Rhodochlamys– All species are highly ornamental in nature.
4. Eumusa – The largest section gave rise to the edible/cultivated banana. The two important species [progenitors] that gave rise to the modern banana include,

Musa accuminata [A genome = AA]

Musa balbisiana [B genome = BB]

The two species [*accuminata* and *balbisiana*] comprise both the wild [inedible] and cultivated [edible] types.

Banana classification and nomenclature

Banana classification and nomenclature have long been a complicated issue. The problem emanated from the simplistic description of plantain, *Musa paradisiaca* in the book, *Species Plantarum*] and dessert banana, *Musa sapientum*. Another common problem confronting banana taxonomists and horticulturists in Southeast Asia is the presence of numerous cultivar names and synonyms in different languages and dialects of the region. They are,

In most cases, the same cultivars are known

TABLE -1: Taxonomy of the family Musaceae with special osome reference to economic products

Taxonomy					
Genus	**Chrom-osome No.**	**Section**	**Distribution**	**No. Species**	**Uses**
Ensete	9		W. Africa, New Guinea	7-8	Fibers, vegetation (soft portions of stem)
Musa	10	Australimusa	Australia to Philippines	5-6	Fiber (Abaca)
	10	Callimusa	Indochina, Indonesia	5-6	Irbanebtaks
	11	Eumusa	S. Indian, Japan, Samoa	9-10	Fruit, Fiber Veg
	11	Rhodochlamys	India, Indonesia	5-6	Ornamentals

by different names in different countries. Occasionally, the same name is applied to distinct cultivars. His simple description was based on a **plantain** cultivar bearing long and slender fruits that remain starchy even when fully ripe. The fruits are cooked before they become palatable and consumed. The male flowers and bracts of plantains are usually persistent and remain as dried relics on the male bud rachis (Fig.1).

While the **dessert** banana bears sweet fruits that are eaten fresh upon ripening. The male flowers and bracts are dehiscent, exposing a clean rachis. The common cultivars of banana and plantain in Latin America and West Africa closely fit the Linnaean descriptions, and the two scientific names remained in wide usage for almost two centuries. However, their adoption in Southeast Asia generated confusions from early on.

In the centre of diversity for bananas, many cultivars are classified as **dual purpose**, wherein the fruits are consumed either fresh or cooked. There are also many starchy, cooking cultivars with short, stout and angular fruits with dehiscent male flowers and bracts. These culinary bananas are distinct from the plantains and cannot be classified under *Musa paradisiaca*. Furthermore, the great diversity of dessert bananas in terms of plant stature, fruit size and color [yellow, green, red and orange] far exceed the rather limited description of the original *Musa sapientum*.

To cope with the wealth in germplasm diversity in its centre of origin, subsequent banana taxonomists applied such descriptive names as *Musa nana* for the Dwarf Cavendish, *Musa rubra* for the red banana, *Musa corniculata* for horn plantain and many others. The situation would have

TABLE -2: Taxonomy Scoring of *Musa accuminata* and *Musa balbisiana*

Character	*Musa acuminata*	*Musa balbisiana*
Pseudostem color	More or less heavily marked with brown or black blotches	Blotches slight or absent
Petiolar canal	Margin erect or spreading, with sacrious wings below, not clasping pseudostem	Margin inclosed, not winged below, clasping pseudostem
Peduncle	Usually downy or hairy	Glabrous
Pedicels	Short	Long
Ovules	Two regular rows in each loculus	Four irregular rows in each loculus
Bract shoulder	Usually high (ratio <0.28)	Usually low (ratio >0.30)
Bract curling*	Bract reflex and roll back after opening	Bracts lift but do not roll
Bract shape	Lanceolate or narrowly ovate, tapering sharply from the shoulder	Broadly ovate, not tapering sharply
Bract apex	Acute	Obtuse
Bract color	Red, dull purple or yellow outside; pink, dull purple or yellow inside	Distinctive brownish-purple Outside; bright crimson inside
Color fading	Inside bract color fades to yellow towards the base	Inside bract color continuous to base
Bract scars	Prominent	Scarcely prominent
Free tepal of Male flower	Variably corrugated belwo tip	Rarely corrugated
Male flower color	Creamy white	Variably flushed with pink
Stigma color	Orange of rich yellow	Cream, pale yellow or pale pink

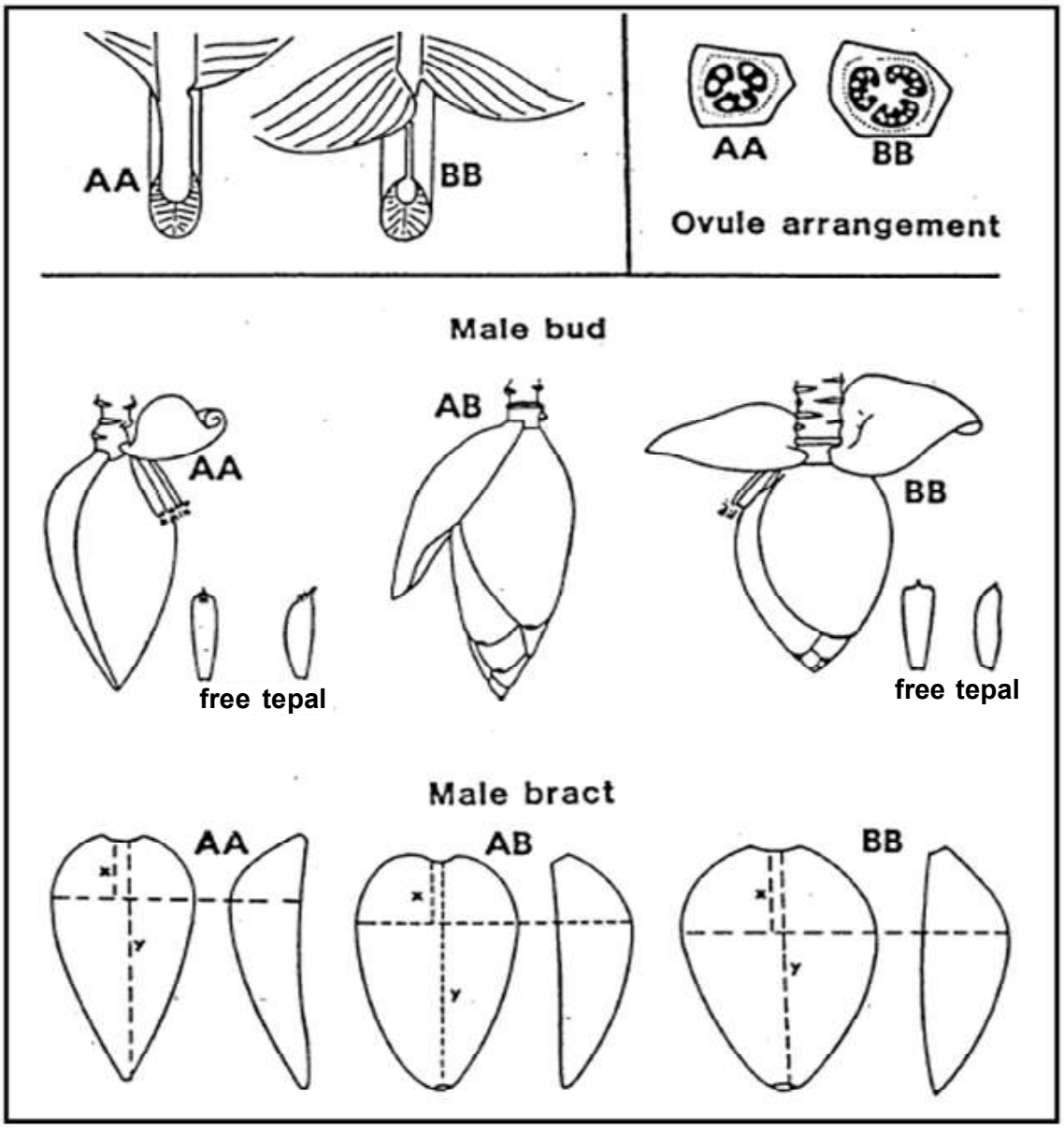

Fig. 1: The important characters used in determining species and genome groups of edible bananas.

aggravated if it were not explained[1,15] the origin of edible bananas and proposed a new classification scheme.

I Botanical taxonomy/classification

Three groups of morphologically distinct cultivars were recorgnized. The first group shows predominantly the botanical characters of *Musa accuminata* while the second group of cultivars primarily exhibit the morphological features of *Musa balbisiana*. The third group possess characteristics that combine the morphological characters of the two wild species and are considered as their natural hybrids.

TABLE -3: Genomic groups according to ploidy and taxonomic score

Genome Group	Score
AA/AAA	15-25
AAB	26-46
AB / AABB	47-49
ABB	59-63
ABBB	67-69
BB / BBB	70-75

II Numerical taxonomy/classification

Workers[5] used a scoring technique to indicate the relative contribution of the two wild species to the constitution of any given cultivar. They identified 15 diagnostic characters to distinguish between *Musa accuminata* and *Musa balbisiana* (Table -2).

For each character in which the variety agreed with wild *Musa accuminata* the score of one was given and for each character in which the variety agreed with wild *Musa balbisiana* the score five was given and the intermediate expressions of the characters were assigned scores of 2, 3 or 4 according to the intensity[6].

The important characters used in determining species and genome groups of edible bananas.

Genomic groups and their respective score ranges are presented (Table-3).

According to this scoring technique, the scores range from 15 [15x1] for *Musa accuminata* to 75 [15x5] for *Musa balbisiana*. A cultivar would have a larger score if it were derived from *Musa balbisiana* and smaller if it were derived from *Musa accuminata*. Pure accuminata cultivars should have scores between 15 to 25 while pure balbisiana cultivars should range between 70 to 75. The hybrids are expected to score between 26 and 69 points and it shows that all the cultivars belonged to six groups of which two were diploid, three triploid and one tetraploid.

Nomenclature of Modern Bananas

Drawing upon their expertise in genetics and their vast experience in cytotaxonomy. Worker[5] concluded that the Linnaean scientific names *Musa paradisiaca* and *Musa sapientum* were based on hybrid cultivars and hence, recommended their abolition.

A major concern about the original terms *Musa paradisiaca* and *Musa sapientum* is their hybrid nature. However, according to rules of the International Code of Nomenclature for Cultivated Plants [ICNCP], hybrids can also be given a scientific name and must carry the prefix **x** to indicate the hybrid nature of the species. In the case of hybrid banana cultivars, *Musa* **x** *paradisiaca* should be adopted as this binomial was published ahead of *Musa sapientum* and in fact recognized as the type species for the banana.

Note: *Musa* **x** *paradisiaca* is applicable to all the hybrids of *Musa accuminata* and *Musa balbisiana* not withstanding their genome composition.

Evolution of modern bananas

The primitive edible bananas are diploids that evolved through the development of sterility and parthenocarpy [vegetative] in both the wild species [AA and BB] and also in their natural hybrids [AB]. In the centre of origin of bananas, the natural distribution of *Musa accuminata* and *Musa balbisiana* overlap, and since the two species are cross compatible, natural hybridization occurred. The hybrids that evolved from the two natural species include diploids, triploids and a few tetraploids in various genomic combinations (Fig.2).

The above figure shows the various pathways leading to the development of edible bananas. It also shows that the two species comprise both wild and cultivated forms. It also projects the important role of interspecific hybridization in the proliferation of edible clones. The parents of hybrid triploids are not limited to the edible diploids but also be traced back to the wild species. The tetraploids could have evolved through the various possible combinations.

III Recent banana classification scheme

Modern taxonomy using isozymes and molecular markers confirmed the multi specific

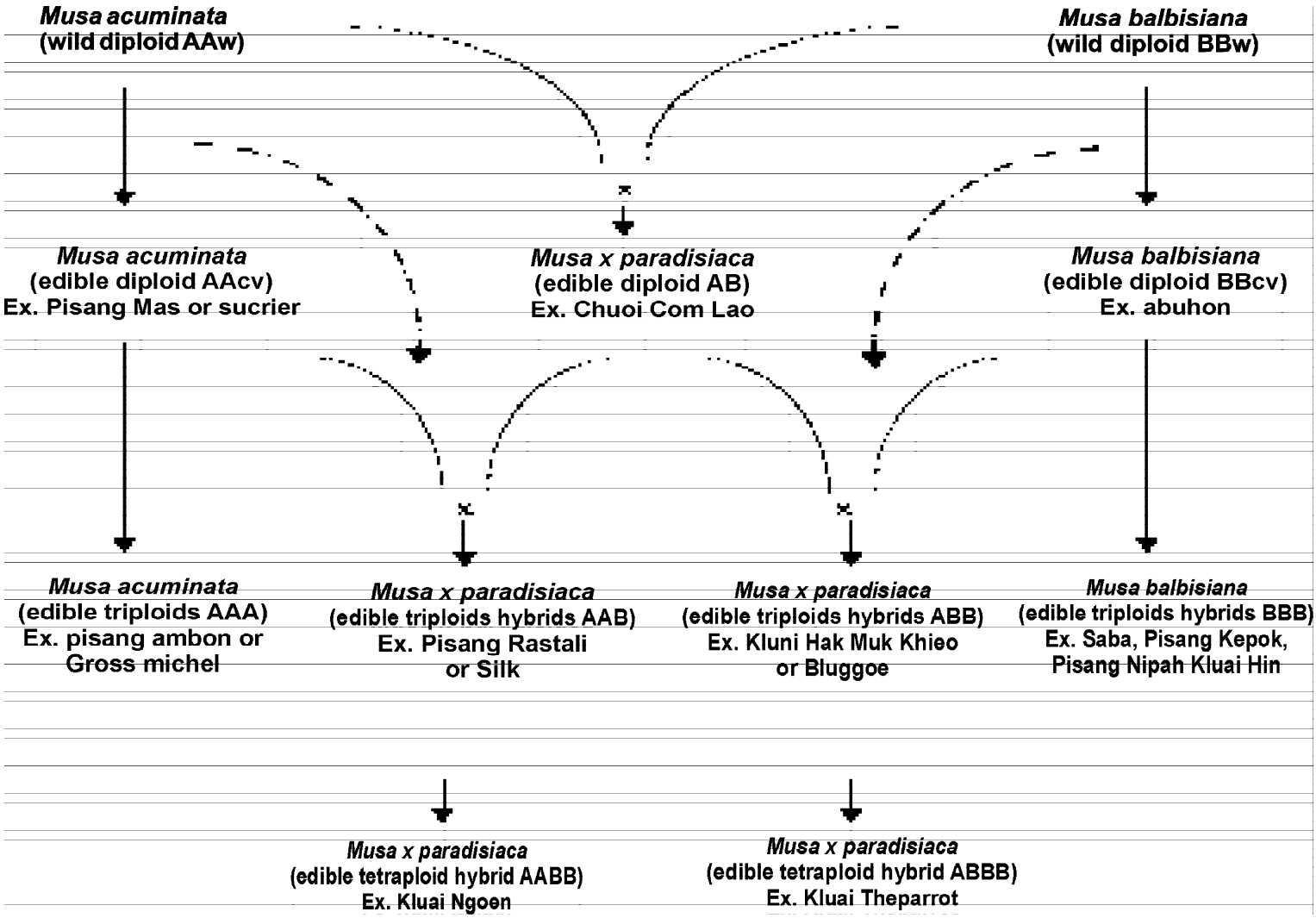

Fig. 2 : Various pathways leading to the development of edible bananas

origin of edible bananas. The application of molecular taxonomy is particularly useful in banana classification because recent studies have shown that chloroplastic DNA is inherited from the female parent while the mitochondrial DNA from the male parent. The use of nuclear or cytoplasmic RFLP probes now enable researchers to precisely determine the maternal and paternal origins of banana cultivars[7].

Two natural species and a hybrid complex make up the edible bananas today. This situation has rendered the identification of cultivars difficult. To cope with the problem, many researchers agreed to adopt the **three tier system** namely – species, genome group and cultivar, in classifying bananas and identifying cultivar names and synonyms in any given region.

The taxonomic scorecard were suggested[4] by a modified version of the original designed[5] was found very useful in segregating the numerous banana varieties into six genome groups. After identifying the species and genome group, the individual cultivars are classified following the latest version of Descriptors for banana [Musa spp.] and Musa Germplasm Information System [MGIS] published by INIBAP and IPGRI.

Banana genomic groups and cultivars

The genomic grouping of bananas and plaintains (groups, subgroups and cultivars) was described[3].

AA genome

Most abundant in Malaysia, Indonesia, India and New Guinea. They are cultivated due to their extra ordinarily sweet and fine quality fruit. In general, they are less hardy than triploid cultivars. The subgroups under this genomic group include,

- ❑ Inarnibal subgroup – *Inarnibal*
- ❑ Lakatan subgroup - *Lakatan*
- ❑ Pisang Lilin subgroup – *Pisang lilin*
- ❑ Sucrier subgroup - *Sucrier*

AAA genome

This genomic group is the largest group under the cultivated bananas. The various subgroups under this group include,

Cavendish subgroup

This is the most significant subgroup of edible bananas.

They are most popular and valuable bananas produced more than 40% world wide.

This subgroup is resistant to panama wilt but susceptible to sigatoka leaf spot.

The various cultivars in this sub group are similar except for their height and characteristics of the bunch and fruit.

Cultivars include,

- ❑ Pisang Masak Hijau [green ripe banana]
- ❑ Giant Cavendish [Robusta/Harichal]
- ❑ Grand Naine [big dwarf]
- ❑ Dwarf Cavendish [Basrai]
- ❑ Extra dwarf Cavendish

Gros Michel subgroup

They can be confused with Cavendish cultivars and can be distinguished by their green/ pale pink undersheath, bottle necked fruit, ripening to full yellow color at ambient equatorial temperatures, short pedicels and extreme susceptibility to panama disease in the America and Africa.

They also produce few seeds when pollinated and hence used for breeding programs.

The cultivars are,

Gros Michel

High Gate / Cocos

Low Gate

Ibota subgroup

Mutika/Lujugira subgroup

Red subgroup - Red and green red cultivars

AB genome

AB cultivars are uncommon. Among these, *Ney poovan* is grown most widely, due to its exceptional flavour. Two edible subgroups,

Kamarangasenge subgroup – Sukari Ndizi [Uganda]

Ney Poovan subgroup – Ney Poovan [India - it produces a sweet subacid fruit with a white flesh.

AAB genome

The Iholena and Maoli-Popo ‘ulu together form the Pacific plantains, the principal Polynesian basic types of bananas. The subgroups under this group include,

Mysore subgroup

Pisang Raja subgroup

Plantain subgroup

Pome subgroup

Silk subgroup

ABB genome

The various subgroups under this group include,

Bluggoe subgroup – Bluggoe, Silver Bluggoe and Dwarf Bluggoe cultivars

Monthan subgroup – Nalla bontha bathees, pacha bonthan bathees and sambrani monthan [India]

Ney Mannan subgroup [India]

Pelipita subgroup

Pisang Awak subgroup

Saba subgroup [Philippines]

BB genome

Parthenocarpy did not evolve in *Musa balbisiana* as it did in *Musa accuminata.* Thus, edible diploid cultivars of the species do not exist. BB clones that are cultivated, such as 'Tani' [Thailand] are grown for their leaves and for animal feed.

BBB genome

Philippine ABB clones such as Caradaba and Saba were classified previously under BBB.

AAAA, AAAB, AABB and ABBB genomes

There are no natural AAAA and very few natural AAAB, AABB and ABBB bananas none of which are important commercially.

Tetraploids that are most common in cultivation are products of the breeding programs. Most notable among them are those from the FHIA program in Honduras like, dessert AAAA, FHIA-02 [aka Mona Lisa], dessert AAAB, FHIA-01 [aka Gold Finger] and cooking or dessert AABB, FHIA-03.

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