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Diversity in the genus *Musa* Focus on Australimusa

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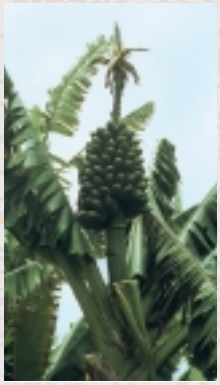

The erect banana bunch of the cultivar Rimina. (J. Daniells, QDPI)

Introduction

The Australimusa section is one of the four sections into which the genus *Musa* is divided (the others being Eumusa, Rhodochlamys and Callimusa). Members of the Australimusa and Callimusa sections have a basic chromosome number of 2n = 20, as opposed to 2n = 22 of Eumusa and Rhodochlamys. There are seven species of Australimusa and a group of parthenocarpic edible types – known as Fe'i bananas – have also evolved within this section. These cultivars are distinguished by their erect bunches and red sap and are found almost exclusively in the Pacific region.

The wild species

Five Australimusa species are indigenous to Papua New Guinea (PNG) (*M. peekelii, M. angustigemma, M. boman, M. lolodensis, M. maclayi*). Two additional species are found outside – *M. textilis* (Philippines) and *M. jackeyi* (Australia). Several studies have been carried out on these species, including those of Cheesman (1950) and Argent (1976) who focused on their morphology. Hybridization studies have been carried out by Shepherd (1988), while Simmonds and Weatherup (1990) used numerical taxonomy to classify the species. More recently, molecular studies have been carried out by Jarret (1992) and Carreel (1994). These different studies have resulted in various theories about the status and relationships

a – ***M. peekelii***
Distribution – New Ireland (PNG). Fruits coloured red at maturity with bright yellow flesh. (J. Daniells, QDPI)

b – ***M. angustigemma***
Distribution – New Ireland (PNG). (J. Daniells, QDPI)

c – ***M. boman***
Distribution – PNG Distinctive cream male bud and similarity in appearance to M. ingens. *By numerical taxonomy and morphology, Simmonds and Weatherup (1990) classified this species with* M. ingens. *Hybridization is possible with* M. lolodensis *(Argent 1976). The inclusion of* M. boman *in Australimusa has been disputed, but the RFLP studies of Jarret* et al. *(1992) and Gawel* et al. *(1992) support its position in this section. While Carreel using molecular techniques found* M. boman *to be distinct from both the Australimusa and Callimusa sections, she noted that in its morphology and geographic distribution it is closer to the Australimusa. (S. Sharrock, INIBAP)*

d – ***M. lolodensis***
Distribution – PNG, Halmaheira, Moluccas Considered by Jarret (1992) as the origin of the Fe'i cultivars. (J. Daniells, QDPI)

between the different species. Shepherd concluded that Australimusa is a recent group and the individual species are isolated more by geographic distribution than genetics. He therefore proposed that all the members should be classified at the sub-species level, rather than having individual species status. Studies by Carreel (1994) of the mitochondrial and nuclear genomes of the species in the section also revealed that, with the exception of *M. boman*, the section contains little diversity. At the mitochondrial level, the species *M. angustigemma*, *M. maclayi*, *M. peekelii* and *M. jackeyi* were grouped together, while at the nuclear level, the species *M. angustigemma* could be distinguished from *M. maclayi* and *M. peekelii.*

e – ***M. jackeyi***
Distribution – north Queensland, Australia. Classified by Argent (1976) as a sub-species of M. maclayi. *This species has an erect bunch and red sap It is little known and considered under threat. (J. Daniells, QDPI)*

f – ***M. textilis***
Distribution – Philippines. Also known as Abaca or Manilla hemp. The fibre extracted from this species was an extremely important source of revenue in the Philippines in the past. It is also grown commercially in Ecuador. (T. Lescot, CIRAD)

g – ***M. maclayi***
Distribution – PNG. Two subspecies are known – M. maclayi *ssp.* maclayi *and* M. maclayi *ssp.* alululai. *These are differentiated by the persistence of the male bracts on the rachis. This species has erect bunches and red sap. The similarity between this species and the Fe'i cultivars led Simmonds (1956) to believe that* M. maclayi *had significantly contributed to the origins of the Fe'i cultivars. (J. Daniells, QDPI)*

Argent (1976) proposed *M. angustigemma* as a sub-species of *M. peekelii.* However, more recent studies indicate that *M. angustigemma* should be treated as a separate species (Jarret *et al.* 1992). Jarret also noted a close relationship between *M. angustigemma* and *M. boman*, a relationship not confirmed by Carreel (1994).

Fe'i cultivars

The domestication of Fe'i bananas, through the processes of parthenocarpy and sterility, occurred independently from the domestication of other types of bananas and plantains. This unique group of cultivars is widely distributed throughout the Pacific islands, from the Moluccas to Hawaii and Tahiti. They are distinguished by their erect bunches, the bright orange colour of the mature fruit and the colour of the sap, which ranges from dark violet to pink (as opposed to the milky or nearly clear sap of most other bananas). In addition, the bracts of the inflorescence of the Fe'i bananas are a bright shiny green, in comparison to the normal dull red or purple of other bananas. These cultivars are poorly understood and reports in the literature are few.

Origin and distribution

Little is known about the origins of Fe'i bananas, although various authors have speculated about possible wild ancestors. Simmonds (1956) suggests that *M. maclayi* is the most likely wild ancestor, while Cheesman (1950) notes their similarity to *M. lolodensis*. This latter view was backed up by evidence from an RFLP-based study by Jarret *et al.* (1992), which indicated that *M. lolodensis* was the closest wild relative of the Fe'i bananas. More recent studies however, have


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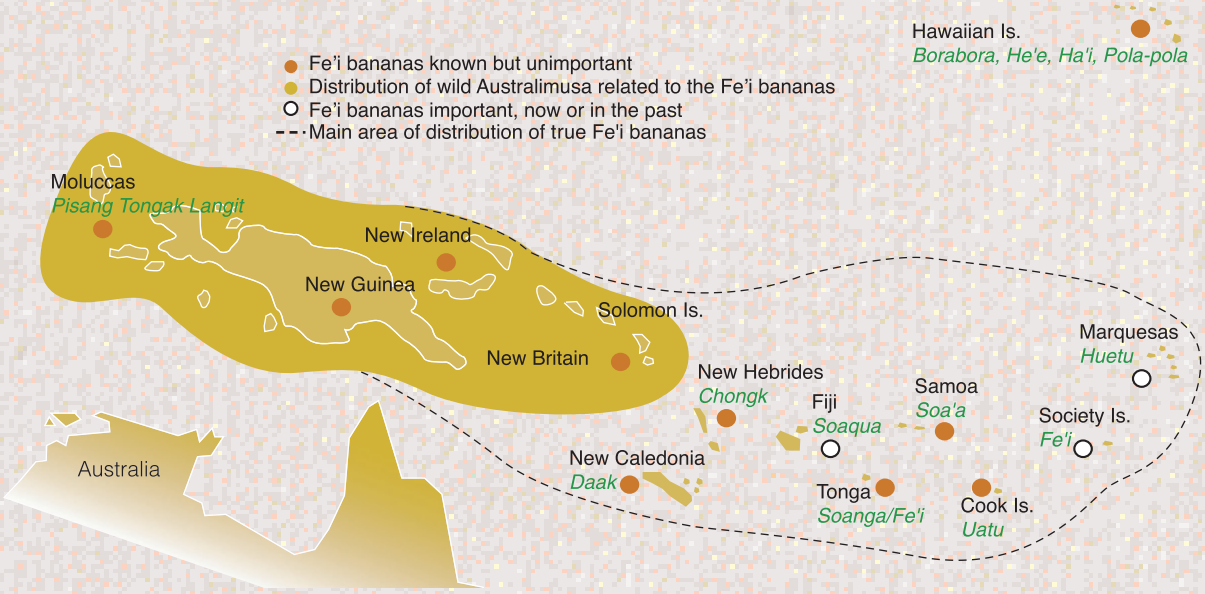

Distribution of Fe'i bananas in the Pacific. Based on Mac Daniels (1947), supplemented by more recent information and the local names of the varieties. Source: Stover, R.H. & N.W. Simmonds (1987).

shown that, while the Fe'i cultivars seem to be closest to the species *M. maclayi, M. peekelii* and *M. lolodensis*, diversity amongst these cultivars is as great as that within the section as a whole, excluding *M. boman*. The possibility of an interspecific origin for the Fe'i bananas therefore cannot be excluded, but further studies are required before this can be confirmed (Careel 1994).

Fe'i bananas are thought to have originated in the New Guinea area and from there, were spread westward through the Pacific by human travellers (Smith *et al*. 1992, Stover and Simmonds 1987). It

Australimusa bananas gathered from the wild in New Ireland. (S. Sharrock, INIBAP)

is known that the cultivars found in the eastern-most range of the group are frequently seeded, while those from Fiji, Tahiti and the Marquesas are rarely, if ever, found with seeds. Thus, as the concentration of seeded forms is in the region of Bougainville and areas further west to north-eastern New Guinea, it is considered that this region is probably the origin of the cultivars (MacDaniels 1947).

Fe'i bananas are a significant food crop in the Marquesas and in the Society Islands, where they have the status of a prestige food and are thus an essential component of feasts and other special occasions. They are also cultivated in Melanesia, the Cook Islands, Samoa, Tonga, Fiji and Hawaii. Botanical and horticultural evidence indicates that the Fe'i bananas have been in the Society Islands for many centuries. Introduction into the Hawaiian Islands is however, known to be more recent (MacDaniels 1947).

There are no archaeological relics or fossils to shed light on the origin and distribution of the Fe'i bananas; however, one Samoan legend states that the mountain and lowland plantains had a fight, in which the 'soaqua', that is the mountain plantain, or Fe'i, won. Flushed with victory, they raised their heads, whereas the vanquished were so humiliated they never raised their heads again. Such legends give some indication of the antiquity of the plant in these islands.

Diversity in the Fe'i cultivars

A complete treatment of the diversity of existing cultivars is available only for Tahiti, where MacDaniels revealed the existence of thirteen distinct forms. Although reports of Fe'i bananas from elsewhere in the Pacific are fragmentary, it appears unlikely that such levels of diversity are to be found outside Tahiti. According to Seeman, in the late 19th century about 18 forms occurred in Fiji. However, MacDaniels did not find any evidence of this wide variety of forms during a visit there in 1927 (MacDaniels 1947). In Tahiti,

MacDaniels distinguished two groups of cultivars. Var. *typica* is characterized by a prolonged male axis and large, imbricate, obtuse bracts on the male bud. By contrast, var. *acutaebracteata* has a short, rapidly degenerating male axis and less markedly imbricate bracts with acute tips.

During banana collecting missions in Papua New Guinea, Sharrock (1989) reported the existence of cultivars with a bunch orientation apparently intermediate between the Fe'i and Eumusa cultivars. The occurrence of both Australimusa and *M. acuminata* genomes in these cultivars has been confirmed by molecular analysis (Careel 1994), although the identity of the particular Australimusa species involved has not been determined. The occurrence of cultivars of hybrid origin thus agrees with the report from Rarotonga of Wilder (1931) in which he describes a variety with a bunch which becomes pendulous as it ripens, though it is erect when it flowers. This characteristic is also found in the variety Tati'a from Tahiti, which has a prolonged rachis which bends down over the bunch when grown in the rich alluvial lowlands, whereas the upland forms have short bracts. MacDaniels suggested that that this lowland form of Tati'a could be interpreted as an intermediate form or phylogenetic transition between the mountain Fe'i and the lowland Eumusa types. A similar type of banana was described by Rumpius (1750) from Amboina, Moluccas. Cultivars have also now been identified from Papua New Guinea containing genomes from *M. acuminata*, *M. balbisiana* and Australimusa (Careel 1994).

Fe'i bananas with a pendulous male bud, confirmed by molecular analysis to be a hybrid between Australimusa and Eumusa. (J. Daniells, QDPI)

Historical importance

There are few historical reports about the Fe'i bananas in the Pacific, but it is certain that such fruit were bartered for nails, hatchets and other goods by explorers of the time, in exchange for fresh food. In the accounts of Wallis (1773) and Cook (1893), bananas and plantains were always amongst the important fresh supplies obtained in Tahiti, and it is believed that the term plantain was applied to all types of bananas that required cooking before eating, including Fe'i bananas.

Banks and Solander (1769) observed 28 kinds of banana and plantain in Tahiti, five of which were called collectively 'Fe'i' by the natives. Ellis (1859) noted in the Society Islands "nearly 20 kinds, very large and serviceable that grow wild in the mountains". He also refers to the native name Fe'i and remarks on the plant's habit of bearing the fruit cluster erect. He states that in several of the islands the Fe'i is the principal food source of the inhabitants.

During his passage to Tahiti in 1835, Darwin noted "I could not look upon the surrounding plants without admiration. On every side were forests of 'bananas' (Fe'i) the fruit of which, though serving for food in various ways lay in heaps on the ground." The rich orange colours of the Fe'i bananas also attracted the attention of Paul Gauguin, a French impressionist painter who visited the Society Islands, including Tahiti, in the late 19th century. Three of Gauguin's canvasses feature Fe'i bananas, suggesting their importance in these islands a century ago: Les Bananes, 1891; La Orana Maria, 1891 and Passage de Tahiti, 1892.

In 1927, when MacDaniels carried out his survey in Tahiti, he noted that the Fe'i banana was still the staple carbohydrate food of the native Society Islanders, although breadfruit, taro and sweet potatoes were also eaten. At this time, the Fe'i banana was more abundant in the local markets than any other foodstuff, with Fe'i types accounting for at least ninety five per cent of bananas on sale. In the villages near where the Fe'i bananas were available, MacDaniels reported that every Saturday, the men and older boys (professional Fe'i hunters) would go into the valleys for the week's supply. They would follow recognised hunter's trails into the upper parts of the valleys to gather the fruit, and would return laden with bunches swinging on a pole carried across the shoulders. These loads were estimated

to weigh as much as 70kg. Such expeditions were observed by Wallis (1773), Darwin (1889) and Moseley (1879).

At the time of his visit (1927), MacDaniels reported that the bananas were sometimes, but not commonly, planted in gardens. The crop was more often found growing 'wild' in the forests. However, if it is accepted that these bananas are not truly 'wild', as in the sense of being self-established by seed, then the question arises as to who planted them and how did they persist so long in the forest. MacDaniels also noted that at the time of Tahiti's discovery (18th century), the Tahitian valleys were populated far up into the hills, beyond the present limits of occupation. Whatever the cause of this – a larger human population than now, or a change in the pattern of occupation – it is clear that people once lived where Fe'i bananas are now only gathered from the 'wild'. However, if each original household maintained a dozen or so plants in its neighbourhood, and if a proportion of these survived after the end of habitation, then the present pattern of distribution is more easily understood. MacDaniels also noted that the Fe'i bananas survived best on talus slopes at the foot of precipitous cliffs. Such habitats are ideal for bananas, which do not compete well with forest species. The instability of talus slopes limits the growth of woody species and such slopes also provide abundant moisture, good drainage and shelter from the wind – features particularly favourable for banana growth (Stover and Simmonds 1987).

Elsewhere in the Pacific, although the Fe'i bananas are much less important, the same general picture emerges, with the crop usually being gathered in the bush from old established plants and occasionally being brought into cultivation if needed.

The fruit of Fe'i varieties, short, round and about the size of a mango. (S. Sharrock, INIBAP)

Uses of Fe'i bananas

As a food

As a food, Fe'i bananas must be cooked, as the ripe raw fruit is unpleasantly astringent. In the past they were usually cooked by roasting in a pit with other food items, but by the early 20th century it was becoming more common for the fruit to be boiled in water. The flesh even after cooking is distinctly starchy, though it may be sweetish if the fruit is allowed to soften before cooking. MacDaniels reported that the sweet pulp of the variety 'Afara' was considered of the highest quality and was sometimes cooked and fed to infants at the time of weaning. According to Stover and Simmonds (1987), sugars account for less than 50 per cent of the total carbohydrate in the ripe fruit. This compares with 73-95 per cent in other bananas. Even the plantains, which are generally considered starchy, are much sweeter than Fe'i bananas

Other uses

In Tahiti, the Fe'i banana has many other uses beyond a foodstuff. MacDaniel described the use of the leaves as plates or trays for cooked food. The leaves were also used as thatching for temporary shelters made in the forest. Darwin stayed in such a hut when he visited Tahiti in 1835. The midribs of the leaves contain long fibres, which can be stripped off and used to make ropes. The Fe'i 'hunters' used these ropes to bind bunches of fruit to the carrying poles.

The dried leaves were used as bedding and for packing, and also made a good fuel for starting fires. Furthermore, small thin pieces of the dried leaves could be used as cigarette papers and MacDaniel reported that the Tahitians appeared to prefer these to the prepared rice papers.

Freshly cut pseudostems are very buoyant and were sometimes pegged and lashed together to make temporary rafts for crossing inland streams and lakes. Fibrous material from the leaves and pseudostem was also stripped off, dried and used to make plaited articles, such as fans and mats.

The reddish-violet sap of the Fe'i bananas is very distinctive and, perhaps due to the presence of stabilizing substances, unusually

stable under exposure to light. This sap is used as a dye and ink. Thus Pétard (1955) noted that, in Tahiti, an early missionary bible was copied with bamboo pens in ink made from Fe'i sap. Similarly, the Samoans decorate the edges of mats with thin strips of banana fibre died pink with the sap.

Australimusa species and cultivars produce red sap. (S. Sharrock, INIBAP)

*An unusual physiological effect of eating the fruit is that the yellow flesh discolours the urine of those who eat it. Reports of the colour vary, with Rumpius reporting it to be "red", Macdaniels "reddish amber" and Pétard "yellow-green". In the original description by Rumpius of a species from Amboina, which he named "*Musa uranoscopus*", he writes: "It is sometimes eaten to provoke urination, which it does without causing pain. As it colours the urine red, however, it is seldom eaten. The Amboinese natives have a superstition that while they cut the stem they must keep still for if they talk the stem will emit blood."*

Present status

It is clear that Fe'i bananas were once an extremely important source of food in the Society Islands. However in recent years their importance has declined considerably, and this is largely attributed to destruction by cattle and pigs, competition from introduced species and the ravages of the banana weevil (Stover and Simmonds 1987). In 1947, MacDaniels reported that the giant morning glory in many places in Tahiti was smothering the Fe'i, and other vegetation, and he considered that even the gathering methods used by the hunters could be in part responsible for the decline of the crop. Apparently no efforts are taken by the hunters to encourage the growth of the Fe'i bananas and frequently young developing shoots are cut back at the same time as the bunch is harvested. Elsewhere in the region, Fe'i bananas are now only found occasionally. However they continue to persist. In Papua New Guinea for example, Fe'i bananas are not a popular food source, but are kept as a back up for when other food is scarce. The varieties tend to be vigorous, resistant to many pests and diseases and require little attention.

Recent advances in biotechnology have made it possible to access a much broader range of diversity. The hardy, disease resistant Fe'i bananas may therefore yet prove to have a valuable role to play in the future of banana production.

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