



Conservation and Commercial Development of *Mangifera* Species (Wild Mangos) in Florida

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In Southeast Asia there is a wide diversity of *Mangifera* species that bear edible fruit, with 69 taxonomically recognized (Kostermans and Bompard, 1993). Among these species, *Mangifera indica* is the most important commercial fruit crop, although *M. lalijiwa*, *M. odorata*, *M. caesia* and *M. foetida*, among others, are routinely cultivated or collected for sale from wild trees. Several *Mangifera* species have been collected and are under evaluation at Fairchild Tropical Botanic Garden in South Florida over the past 15 years. More than 33 accessions of *Mangifera* species from Borneo, peninsular Malaysia, Thailand, Hawaii, and Puerto Rico have been accessioned into the genetic collections of Fairchild Tropical Botanic Garden since 1994. *Mangifera applanata* (Assam kepeng), *Mangifera caesia* (wani), *M. pentandra* (Assam poah), *M. griffithii* (rancha ranca), *M. laurina* (Mangga ayer), *M. quadrifida* (Assam kumbang), *M. rubrapetala* (raba), *M. casturi* (kastooree), *M. lalijiwa* (honey mango), *M. odorata* (kuini), *M. pajang* (pajang), *M. torquenda* (lamatan), *M. foetida* (bachang), and other possible *Mangifera* species are under evaluation. These wild, edible mangos are in critical danger of extinction and represent an important resource for the future of mangos. Data presented includes their adaptability to modern cultivation and potential as commercial crops.

Street markets of Borneo, Malaysia, and Indonesia seasonally display wild mangos for sale, just as they have for hundreds of years. Most of the *Mangifera* species have edible fruits. We have documented experiences based in use of this fruit from local communities, markets and the surrounding countryside in Borneo, Peninsular Malaysia, and Indonesia from 2004.

Materials and Methods

Over 33 accessions of *Mangifera* spp. were identified and collected from private residences, commercial orchards and public and private experimental farms in different regions of Malaysia, Indonesia, and Brunei Darussalam. Other accessions were introduced from Hawaii, Puerto Rico, and Brazil with the knowledge of their provenance. All accessions were collected and introduced into the United States as scions with the leaves removed. Scions were washed in soap and water, air-dried, wrapped in parafilm, and placed in plastic bags for transport. Transport time ranged from 2–12 d, depending on the species and location of collecting expedition. Eight to 12 scions were collected per species.

All species were grafted by the authors using a side veneer or cleft method commonly used for fruit crops in Florida. *Mangifera indica* 'Turpentine', *Mangifera rubrapetala*, *Mangifera casturi*, and *Mangifera odorata* rootstock were used because the importation of *Mangifera* seeds from Southeast Asia is restricted by quarantine laws to protect against the introduction of the mango seed borer [*Sternonchetus mangiferae* (F)]. These species are locally available in South Florida for use as rootstock.

We have outlined their potential as edible fruit crops, rootstocks, and as sources of genetic diversity for the future breeding of disease resistance and desirable horticultural traits in the modern mango. The importance of conserving these species and their genetic potential has been clearly recognized by the scientific

community. However, nearly two decades after their taxonomic description, little has been done to advance these goals. This is due mainly to a lack of practical horticultural information about their care and domestication, and the challenges inherent in the collection, curation, and development of genetic material.

Results and Discussion

Recording experiences with local communities and visiting markets provided basic information about the use of these species, and their economic potential. In most of the places we collected wild mangos from traditional or indigenous systems of knowledge and practice that have developed and accumulated over generations. These systems form the basis of local-level decision-making in agriculture, food production, human and animal health, and natural resource management.

The reported results are preliminary. We recorded experiences based on the use of fruit from local communities, markets, and the surrounding countryside in Borneo, Peninsular Malaysia, and Indonesia. Inhabitants consume many of these species fresh or mixed with pepper and spices in sambal. Others use their leaves as a vegetable. *Mangifera pajang*, *M. caesia*, and *M. casturi* have exceptionally beautiful growth habits with colorful flowers making them suitable as ornamentals for the tropics.

Collection and domestication has been a long and complex process and has only just begun (Campbell and Ledesma, 2010). It is necessary to approach new research about the use of these wild mangos and importance in rural economies, especially statistics concerning their value and reliable methods for measuring their contribution to farm households and the rural economy.

Wild edible mangos are in critical danger of extinction and represent an important resource for the future of mangos. Data presented includes their adaptability to modern cultivation and potential as commercial crops.

The introduction of improved selections or clones of *Mangifera* species and the identification of suitable economic potential and commercial development of *Mangifera* species has been con-

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Table 1. Ex situ *Mangifera* species at Fairchild Tropical Botanic Garden, conservation status and economic potential

Species	Provenance	Conservation status	Economic potential and description
<i>Mangifera altissima</i>	Sabah, Malaysia, Borneo	IUCN Red List. Extinct in the wild.	Fresh fruit, breeding, ornamental
<i>Mangifera applanata</i>	Sarawak, Malaysia, Borneo		Rootstock for <i>Mangifera</i> sp., breeding. Grows in high elevation 1800 m.a.s.l. It has a flattened fruit, very tart, used for pickles. Seeds are very hard, and with longitudinal strips.
Common names: asam pelipisan, peleepeesan			
<i>Mangifera caesia</i>	Sarawak, Malaysia, Borneo	IUCN Red List. Extinct in the wild.	Fresh fruit, breeding, ornamental, flooded soil. Generally restricted to the wet tropical lowlands below 450 m elevation, frequently in inundated areas, along riverbanks. It is common to find it cultivated in villages in Sarawak, especially in the Limbag Division. Fruit can reach 500 g and some can be long or oblong in shape. It is mono embryonic. The flesh is white and juicy. Some can be sweet, other can be more acid. Both have a unique, strong aroma and taste. In Malaysia, this is one of the most common and valuable mango species. Fruit is eaten when it ripe or dipped in chili with sugar and dark sauce. Used to make 'sambal', 'jeruk' and eaten with fish. Flesh is also pickled and preserved with salt in jars. They used for juices. Some fibreless clones command a high price in local markets. The wood is light red marbled with yellow, used for light construction.
Common names: Belunu (sweet fruit), Binjai (tart fruit), Bua Buda			
<i>Mangifera casturi</i>	Kalimantan, Indonesia, Borneo	IUCN Red List Extinct in the wild.	Fresh fruit, breeding, ornamental, Inter stock, rootstock for <i>Mangifera</i> sp. <i>M. casturi</i> is a vigorous tree that forms a tight, upright canopy with shiny, dark green leaves, contrasted with bright red new growth. Tree can grow up to 30 m tall, with Inflorescence up to 30cm long, multiflowered than smell like jasmim. Flowers are visited by honeybees and flies. Fruit are small compared to other species of mangos. It weighs around 50 to 84 grams each. Immature fruit are green, and when ripe the color changes to brown or purple-black and has a shiny surface. It is polyembryonic. The flesh is orange with fiber with a unique sweet flavor than taste like lychee with a distinct aroma. It makes a handsome tree.
Common names: kastoorée, Air mawar (Rose water)			
<i>Mangifera foetida</i>	Sarawak, Malaysia, Borneo		Breeding. Generally restricted to the wet tropical lowlands below 1000 m elevation. There are some round or elongated fruit. Large ones are sold to the market for better price. The fruit is savory with a strong turpentine flavor and aroma. It is monoembryonic. Normally is eaten fresh. It is used for curries or pickles. Immature fruit is used as a vegetable. Peeled and soaked in salty water, sliced to make salad (tujak). They use it to get the acid for preparation of sambal (green pepper with lemon, and sometimes add curries). Leaves are mash to use as antiseptic, and bark is used to make lotion for treating ulcers
Common names: Bua Laamb (Tart); Bachang			
<i>Mangifera griffithii</i>	Sarawak, Malaysia, Borneo		Fresh fruit, breeding. It is a very tall tree, sometimes cultivated near villages. Fruits are purple when mature. The flesh is deep orange, very juicy and with fiber. It has thick skin with fragrant resinous flavor. Flesh is very sweet and pleasant. Ripe fruits are eaten by hand, normally sucked. Immature fruit also used to prepare pickles.
Common names: Assam Kundang, Asam-raba (larger fruit), Raba pisang, Bua Keramut			
<i>Mangifera laljiwa</i>	Bali, Indonesia		Fresh fruit, breeding. The name "madu" means "honey" and they appear in great quantities in local markets of central Java. Tree is small with leathery leaves. The fruit is 250 gr. with green skin. It is monoembryonic. Flesh is white pale yellow with particular brown honey pockets in the flesh. Fruit are very sweet and aromatic with a distinguish honey flavor. It is medium size tree, and productive. Flowers are fragrant, with pyramidal panicles with a fragrant aroma to jasmine. Honey bees often visit flowers.
Common names: Honey mango, mango Madu			

Continued.

Table 1. Continued.

Species	Provenance	Conservation status	Economic potential and description
<i>Mangifera laurina</i> Common name: Mangga ayer	Sabah, Malaysia, Borneo		Fresh fruit, breeding. Fruit are about 200 g, yellow green skin and juicy flesh. There are some differences in the shape of fruit and flavor in different accessions of <i>M. laurina</i> in our collection. All are polyembryonic with big seeds and fiber. They are well adapted to wet climates and the flowers and fruit seems to be resistant to anthracnose.
<i>Mangifera odorata</i> Common name: Kuini	Sarawak, Malaysia, Borneo		Fresh fruit. A popular garden fruit, propagated by seeds. The fruit is green skin with yellow to orange flesh with a strong fragrant smell. Sometimes called Durian mango. The seed is flat and hairy. The skin is peeled off before consumption. The sweet fruit is eaten outright or juiced. Immature Kuini is also used in pickles, or mixed with raw fish and chilies. Fruit its sale by fruit and by bushes. Prices vary by quality and size. Fruit comes in different shapes, always green skin, but different textures, sugar content, and quality.
<i>Mangifera pajang</i> Common name: Asam Embawang	Sarawak, Malaysia, Borneo		Fresh fruit, breeding, ornamental, vegetable. Fruit fragrant, up to 3 kg. It is monoembryonic. Fruit brown thick skin, with yellow flesh. There are differences in the shape fruit, some are round others are oblong, and some has less fiber. Flesh juicy and tart, some are sweet with slight tang after taste. Fruit are eaten out of hand when ripe, or it can be used immature in pickles and chutneys. This fruit is eaten as an appetizer or sambal made of the fruit slices, belacan, red chilli, salt, and sugar. Tree majestic columnar tree than grows over 40 feet, dark leaves. The leaves are edible, used as a vegetable. Often sold at market.
<i>Mangifera pentandra</i> Common name: Assam poah	Sarawak, Malaysia, Borneo		Breeding. Tree is tall with leathery leaves, small white yellowish flowers. Fruit is 50–80 g, pale orange, sweet, and juicy with big round stone. Leaves are used as an astringent.
<i>Mangifera quadrifida</i> Common name: Assam kumbang Betong	Sarawak, Malaysia, Borneo		Fresh fruit, breeding, rootstock. Fruit is deep purple with bright orange flesh. Skin is leathery. They vary in size and shape. The fruit are sweet to sour in taste, either consumed fresh or processed into jams or jellies. Young fruits can be made into pickles, chutneys, or dried as preserves; and also can be cooked as dishes. <i>M. quadrifida</i> as a common species in the forest, but this species is also being cultivated or semi-cultivated in home gardens applied. and orchards, where trees are managed for harvesting. Herbicide and fertilizer are commonly
<i>Mangifera rubrapetala</i>	Sarawak, Malaysia, Borneo	IUCN Red List. Extinct in the wild.	Inter stock, rootstock for <i>Mangifera</i> sp. The tree is medium size with an open canopy, and very productive. Fruit grows in clusters with small yellow fruit. The fruit are rich in flavor with fiber and big seed. They usually are polyembryonic.
<i>Mangifera torquenda</i> Common name: Lamatan	Sarawak, Malaysia, Borneo		Interstock, rootstock for <i>Mangifera</i> sp. The fruit are about the size of oranges, and normally completely round. It has strong odor rivaling those of <i>M. pajang</i> . Their flesh ranges in taste from sour to quite sweet. It detaches easily from the seed and fresh fruits are quickly prepared by slicing them all the way around and twisting the sections in opposing directions like you would do with a peach. The fruit is used in the preparation of many local dishes including “Ulam” and is also highly desired for pickles.



Fig. 1. Many wild mangos have excellent tolerance (perhaps even resistance) to anthracnose. The trees will bear fruit in wet climates where the common mango rarely reaches maturity, offering a possibility for rootstocks or breeding material. Examples include: (A) *Mangifera torquenda*; (B) *Mangifera pajang*; (C) *Mangifera quadrifida*; and (D) *Mangifera caesia*.

ducted by the Fairchild Tropical Botanic Garden, Homestead, FL, for the past two decades. Many of the horticultural challenges have been confronted, including the identification of possible rootstocks and protocols for their propagation to allow for the development of these potential resources for the modern mango industry (Fig. 1).

Table 1 (previous page) summarizes the introduction of improved selections or clones of each species since 2004. Fourteen *Mangifera* species from Malaysia, Borneo; Indonesia; Borneo, Indonesia, and Seychelles Islands have been accessioned into the genetic collections of Fairchild Tropical Garden in Miami, FL. The species collected were *Mangifera altissima*, *M. caesia*, *M. casturi*, *M. foetida*, *M. griffithii*, *M. lalijiwa*, *M. laurina*, *M. odorata*, *M. pajang*, *M. pentandra*, *M. quadrifida*, *M. rubrapetala*, *M. torquenda*, *M. applanata* and *M. zeylanica*. There are additional *Mangifera* accessions collected on the basis of their potential for breeding purposes and fruit quality that remain unidentified.

Identification and classification of species has to be reviewed. Herbarium specimens and taxonomic review are proceeding. The DNA analysis using several laboratory teams and research groups is also underway to aid in the proper identification of these accessions. There is a possibility of wild hybridization between species and this may be detected with genetic analysis. However, rootstocks and information about potential graft compatibility of each species is still a challenge. Graft compatibility and horticultural traits must be further evaluated under a wide range of conditions. Other species must be evaluated and suitable rootstocks identified. In this way we can begin to collect improved clones that will better serve our horticultural needs.

Literature Cited

Campbell, Richard J. and Noris Ledesma 2010. Update on new *Mangifera* species in Florida. In: Proc. of the Ninth Intl. Mango Symposium, Number 992, China. p. 95–99. Intl. Soc. Hort. Sci.