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Notes on the Natural History of the Johore Banana, *Musa gracilis* Holttum

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Abstract: *Musa gracilis* is the only wild banana species in Johore, Malaysia. In Kelantan and Trengganu it grows together with *M. acuminata* Colla. *M. gracilis* and *M. violascens* Ridley (in section Callimusa) are compared. Both are endemic to Peninsular Malaysia but their geographic distribution does not overlap. The anatomy of the seed of *M. gracilis* is described and the function of the chalazal mass is discussed. Growth (increase in stem height and rate of leaf production), its ecology and conservation status are also mentioned.

INTRODUCTION

Simmonds (1955) recognised only three wild species of banana in Peninsular Malaysia, namely *Musa acuminata, M. gracilis* and *M. violascens. Musa acuminata* (for which he recognised several forms) is the tallest (it may grow up to 3 m or more) and its inflorescence is similar to that of the cultivated banana in being pendant and having brownish-red bracts. It is pollinated by bats. The other two species, *M. gracilis* and *M. violascens,* have erect inflorescences with polished bracts and the latter is pollinated by birds (Holttum, 1969). These two species, which are included in Section Callimusa, have similar barrel-shaped seeds (Fig. 1A), as compared with the subglobose, angular ones of *M. acuminata,* which belongs to Section Eumusa.

Musa gracilis is the shortest banana in Peninsular Malaysia. Some stems produce an inflorescence on reaching about a metre tall, but more frequently the stem is between 120–130 cm tall, although a few stems can grow up to 194 cm. It is distinguished from *M. violascens* by the characters shown in Table 1.

There is some variation in the colour of the bract in *M. gracilis.* The Ulu Endau, Johore, population is uniform in all plants possessing almost completely white bracts (except for the green tip). However, populations in Trengganu and elsewhere in Johore have pale rosy-purple or pale purple bracts.

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Table 1. The morphology of *Musa gracilis* and *M. violascens*. (diagnostic characters are in italics)

Character	*Musa gracilis*	*M. violascens*
Stem ht at flowering (cm)	145–180	98–194
Stem diameter (cm)	20	*6.5–15*
Type of clump	dense	*well-spaced*
No. leaves in crown	5–7	(7–) 10 (–15)
Angle of young leaves	arched, ± horizontal	arched, ± horizontal
Leaf shape	broadly lanceolate	narrowly lanceolate
Size of largest leaf in crown (cm)	200 by 42	128–192 by 28–41
Length petiole (cm)	88	*53–64*
Leaf apex	acute	acute
Length of peduncle	7	*30*
Total length of inflorescence (cm)	62	70
No rows of flowers at node	2 (biseriate)	*1 (uniseriate)*
Shape of male bud	heart-shaped	*spindle-shaped* (Fig. 2)
No male flowers per bract	3 + 6	2
Colour male flowers	cream, orange towards tip	*grass-green*
Colour male bracts	white flushed pinky-violet with green tip	*white or pale pinky-purple*, with green tip
Shape of male bracts	ovate	*lanceolate*
Size of male bracts (cm)	11 by 4	*12–19* by 3–5
Female bracts	withering and persistent, (sometimes deciduous)	*deciduous*
No bananas per hand	4 + 4 or 5	*2 or 3, rarely 4*
No fruits per infructescence	64–72	*6–15*
Fruit shape	squat, strongly angled	*elongate*
Fruit size (cm)	6 by 3	*14–15* by 3.5–4.5
Fruit colour	dark green	*almost white to glaucous green*
Fruit stalk	± sessile	*1–2 cm*
Apical aperture of seed	wide	wide

ANATOMY OF THE SEED

Musa gracilis belongs to the group of bananas (section Callimusa) with barrel-shaped seeds. Its basic anatomy conforms to that described by McGahan (1961) for *M. balbisiana* Colla, which belongs to the Eumusa section having subglobose, angular seeds. A salient difference in *M. gracilis* is the wide aperture of the apex and the thin-walled parenchymatous tissue immediately inside, which on exposure to air dries rapidly to leave a hollow cavity which occupies about half the interior of the seed (Fig.1B). This tissue is interpreted as part of the chalazal mass. In *M. balbisiana* the parenchymatous tissue of the chalazal mass forms a small central core surrounded by cells packed with a red-brown substance. Compared with

M. balbisiana, the parenchymatous tissue in the seed of *M. gracilis* is greatly enlarged.

A longitudinal section of the fresh seed of *M. gracilis* (Fig. 1B) shows that the chalazal mass comprises large, thin-walled parenchymatous cells (Fig. 1C) which contain tannin and occasionally raphids. Below this are about 8 layers of thin-walled cells completely filled with a red-brown material (Fig. 1D). The testa divides the chalazal mass from the perisperm. The perisperm cells (Fig. 1E) are congested with compound starch grains and in some cells a solitary protein crystalloid. Embedded in the basal part of the perisperm and surrounded by the micropylar collar (Fig. 1B, mc) is the embryo (e). Its haustorial cotyledon (hc) is embedded in the perisperm.

The testa is extremely hard and is almost black when mature. It consists of macrosclereids (Fig. 1F, ms) with conspicuously pitted, thick walls, which are impregnated with a dark brown material. In places externally the epidermis persists, but mostly it has sloughed off. The outer 2 layers of macrosclereids are perpendicular to the longitudinal axis of the seed, while the inner 12–15 layers are parallel. Interior to these is a layer of multiluminate sclereids (mls). McGahan (1961) considered these outer layers to be derived from the outer integument and the ones interior to them to be derived from the inner integument. The inner layers (iw) comprise 2 layers of elongate thinner-walled sclereids with a thick cuticle (c) between them and the outer layers. The sclerotesta does not extend over the apical aperture, where the parenchymatous cells of the chalazal mass are covered by a single layer of suberised cells.

Histochemical tests (Table 2) confirm the anatomical findings that the perisperm contains starch and protein, while the parenchymatous tissue of the chalazal mass does not. The fact that the parenchymatous tissue turns brown on exposure to air also indicates that tannin is present in its cells.

Table 2. Histochemical tests on seed contents of *Musa gracilis*.*
(+ positive result; – negative result)

Test	Substance tested	Perisperm	Parenchymatous tissue of chalazal mass
Iodine and potassium iodine	starch	+	–
Biuret	protein	slightly +	–
Benedict	reducing sugars	–	–
Ninhydrin	amino acids	–	–

* carried out by Dr Z. C. Alang.

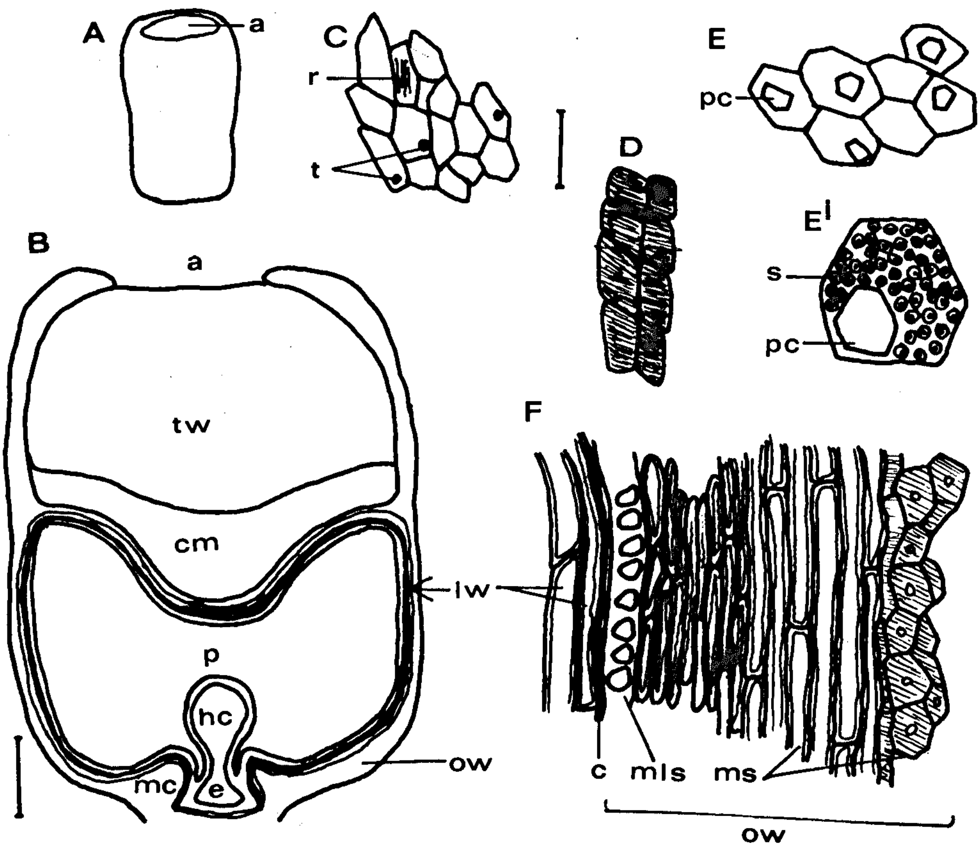

Figure 1. Anatomy of the seed of *Musa gracilis.* (A) exterior of seed showing the wide apical aperture, a. (B) L. S. seed, tw – thin-walled cells of chalazal mass; cm – cells of chalazal mass with brown-red cell contents; p – perisperm; hc – haustorial cotyledon; e – embryo; mc – micropylar collar; iw – inner wall of testa; ow – outer wall; scale bar = 1 mm. (C) thin-walled cells of chalazal mass; r – raphids; t – tannin; scale bar = 100 μm. (D) cells of chalazal mass with brown-red cell contents. (E) & (Ei) cells of perisperm, pc – protein crystalloid, s – starch grain. (F) testa, c – cuticle, mls – multiluminate sclereids, ms – macrosclereids.

These tests therefore confirm that the parenchymatous tissue of the chalazal mass does not have a storage function. The fact that it completely shrivels on exposure to air (because it is exposed by the large aperture at the apex) suggests that it largely consists of water. This is supported by the large weight loss (60 per cent) on drying (100 seeds had a fresh weight of 10.7 g and a dry weight of 4.6 g). McGahan (1961) found in *M. balbisiana* that the red-brown contents of cells at the base of the chalazal mass contained a gelatinous substance. This may function as a buffer by retaining water after the parenchymatous tissue has shrivelled, so preventing the embryo from drying out.

There appears to be a relation between water loss from the parenchymatous tissue of the chalazal mass and germination. When freshy removed from the fruit, the parenchymatous tissue is turgid. At this time, the seed has the ability to germinate immediately. However, once this tissue has shrivelled, the seed becomes dormant.

BIOLOGY OF *MUSA GRACILIS*

Bananas exhibit several characters of weeds, such as rapid growth, a short maturation period and dispersal by seed. Rapid growth is illustrated by the cultivated banana which produces a new leaf every 7–10 days, flowers after producing between 35 and 50 leaves (at the age of 9 or more months) by which time it is between 2 and 9 m tall (Purseglove, 1972).

Studies on young plants grown in pots show that the first two leaves of *M. gracilis* consist of the leaf sheath only, thereafter leaves are produced with a lamina of increasing size.

Monitoring the growth of young plants of *M. acuminata, M. gracilis* and *M. violascens* showed that a new leaf was produced at between one to four weekly intervals for all three species (Table 3). The number of leaves in the crown remained more or less constant, the slower leaf production of *M. gracilis* being offset by the longer life of individual leaves (12–18 weeks) compared with 6–12 weeks for *M. acuminata* and *M. violascens* (Table 3). Over a period, the slightly faster leaf production and longer internodes of *M. acuminata* resulted in a taller plant (an increase in height of 28 cm in 36 weeks). In contrast, *M. gracilis,* which has very short internodes and slightly slower leaf production, produced a shorter stem (22 cm) in the same period.

Table 3. Leaf production in young plants of three Malayan banana species.

	Musa gracilis	*M. violascens*	*M. acuminata*
Leafing interval (weeks)	(1.3–) 2.3 (–3.5)	(1–) 2 (–3.5)	(1–) 1.8 (–4)
Leaf longevity (weeks)	(12–) 14.5 (–18)	(6–) 9 (–12)	(6–) 9 (–12)
Total no. leaves produced within 36 weeks	17	21	26

Monitoring the growth of plants of *M. gracilis* in the wild at Ulu Endau over a ten-week period showed that during that period the average increase in height for plants between 60 and 127 cm tall was 14 cm (range 6–30 cm) with three new leaves (range 2–6) being produced. The shortest plant to flower in this population was 120 cm tall suggesting that, at a rate of 1.4 cm per week, 120 cm may be attained after 85 weeks. This is probably an underestimate as growth (as measured by increase in stem height) is much slower during the seedling phase.

In potted plants, suckers were produced first in. *M. gracilis* (after 39 weeks) compared with *M. violascens* (after 51 weeks) and *M. acuminata* (not at all in 51 weeks). The suckers of *M. gracilis* have a rhizome which displaces the sucker about 5 cm from the main stem resulting in an open clump system. The suckers of *M. violascens* grow much closer to the main stem producing a dense clump of stems.

The production of suckers increases the number of seeds produced per plant. An infructescence of *M. gracilis* produces between 6 and 12 fruits and each fruit contains between 60 and 130 seeds, giving a potential seed crop of between 360 and 1,560 seeds per stem. Since the interval between germination and seed production is well over a year (estimated at least 85 weeks), the production of suckers (after 36 weeks) shortens the interval between inflorescence production, as well as enabling an individual plant to produce more seed.

Figure 2. Male flower bud of *Musa gracilis*, the bract open and the flower exposed.

Pollinators were not observed at Ulu Endau but from the similar inflorescence structure to *M. violascens* and *M. campestris* Becc. (which in Sarawak was observed being visited by birds), it is likely that *M. gracilis* is also bird-pollinated. Several types of insects, such as flies and the butterfly, *Ancistrodes nigrita*, visit the male flowers to suck nectar from the base of the perianth. These are not pollinators as they do not collect pollen or come into contact with the anthers.

At Ulu Endau, the banana populations suffered heavily from periodic visits by elephants, which uproot and eat the stems. The devastation is extensive, not only from the number of stems taken, but also from the effect of trampling. The populations recover by the growth of young suckers.

ECOLOGY

Bananas are forest weeds which are intolerant of shading and root competition (Simmonds, 1962). Like other wild bananas, *M. gracilis* is a plant of forest fringes and its abundance has probably increased with the widespread logging of the forests in Johore and Trengganu. It is particularly common along the edge of old logging tracks. Of 15 herbarium collections which describe its habitat, 13 were collected from secondary or disturbed habitats. Its habitat in virgin forest is the banks of open streams.

Compared with *M. acuminata* and *M. violascens*, *M. gracilis* appears less tolerant of exposed windy locations. This may in part be due to the angle at which the leaf is held. The leaf of *M. acuminata* is held at 45° to the horizontal and gusts of wind cause the petiole and midrib to rotate in a circular manner (Fig. 3a). The leaf of *M. gracilis* is arched and the upper half is held almost horizontally. Wind movements cause a stress at point 's' (Fig. 3b), which result in the midrib breaking at this point.

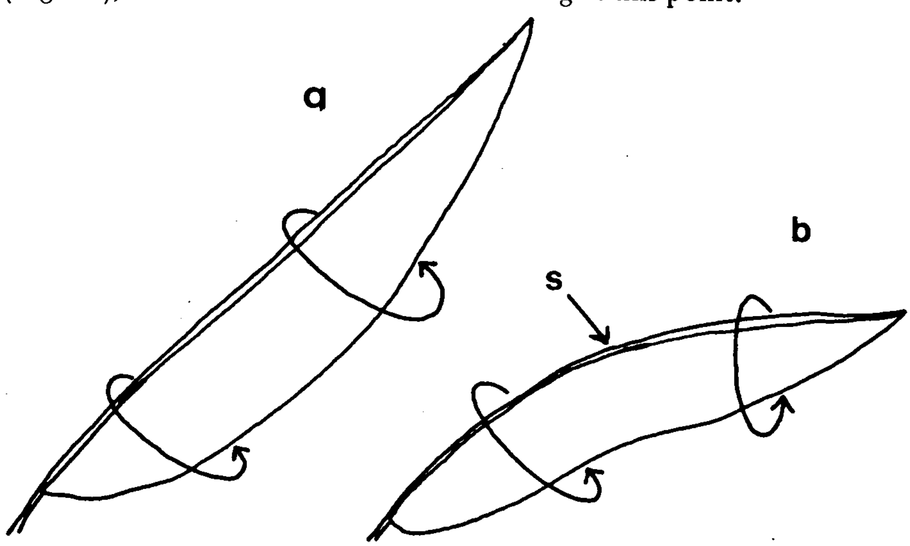

Figure 3. Angle at which the young banana leaf is held, showing the direction of rotation of the lamina by wind. (a) *Musa acuminata*, (b) *M. gracilis*, s – stress point).

Banana seeds are some of the few tropical seeds that exhibit dormancy. They will germinate as soon as they are removed from the fruit, but once covered by soil, they become dormant and can retain their viability for several years (Simmonds, 1962). Once the soil is exposed, banana seedlings quickly appear in great numbers. This is probably due to the heating of the soil when exposed to full sunlight. Nik Muhamad & Kamaruzaman (1987) recorded an increase in maximum soil temperature from 23.5°C in virgin forest to 28°C in logged-over forest. Germination studies carried out by Chin (pers. comm.) show that moist heat treatment (35–40°C for one week) effectively breaks dormancy in the seeds of *M. acuminata*, *M. gracilis* and *M. violascens*.

GEOGRAPHIC DISTRIBUTION

Musa gracilis and *M. violascens* are endemic to Peninsular Malaysia. In contrast, *M. acuminata* has a widespread distribution from India to Samoa.

The distribution of *M. gracilis* does not apparently overlap with that of *M. violascens* (Fig. 4). On the west coast *M. gracilis* has been collected as far north as Batang Melaka, Malacca, and *M. violascens* as far south as Bk. Tampin, Negri Sembilan. On the east coast *M. gracilis* has been collected throughout Trengganu and from Ulu Lebir in Kelantan. *M. violascens* has not been collected further east than Sg. Tahan, Pahang.

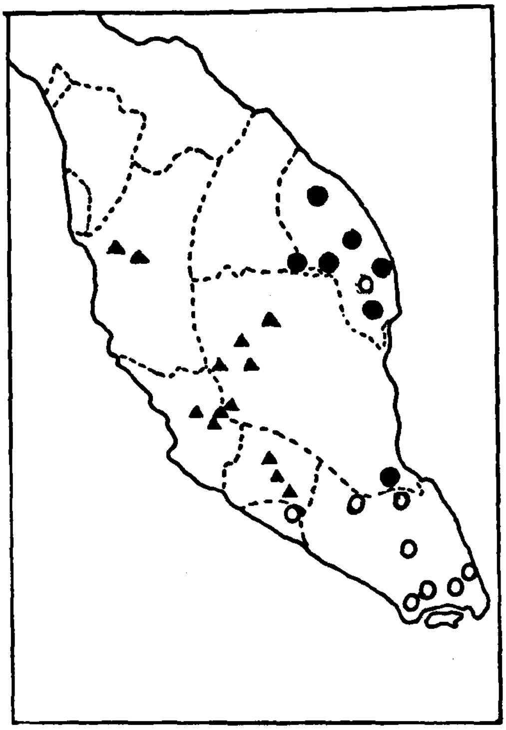

Figure 4. Distribution of *Musa gracilis* and *M. violascens* based on herbarium collections. (o *M. gracilis* collected between 1890 and 1940; • *M. gracilis* collected after 1960; ▲ *M. violascens*).

In Peninsular Malaysia, *Musa acuminata* has been collected from all states, except Johore (Simmonds, 1955). In Trengganu and Kelantan, it grows together with *M. gracilis*. *Musa gracilis* is, therefore, the only banana in Johore.

Information based on collections in herbaria is, however, only sketchy as there is a general reluctance among botanists to collect such large and unwieldy plants. There is still much to be learned about the distribution of *M. gracilis* and *M. violascens* and whether their distributions overlap.

Compared with *M. violascens,* which is common from the lowlands to hills at 1000–1500 m, *M. gracilis* is a lowland plant. It usually occurs below 170 m, but on G. Panti, Johore, it has been collected at 333 m in *kapur* forest (Corner *SFN 30056*).

There is no accepted local name for *M. gracilis.* Regional names include *pisang kerteh,* Kelantan; *pisang onik* and *pisang wek,* Trengganu (Simmonds, 1955); and *pisang sot,* the *Orang Hulu* name at Kampung Peta, Sg. Endau, Johore.

CONSERVATION STATUS

Musa gracilis, in common with other banana species, is favoured by logging which provides extensive habitats along abandoned logging trails. At one time it was thought to be reduced to two small, separated populations (in Lesong F. R., Pahang and Kemaman, Trengganu) and its conservation status was considered as vulnerable (Ng, 1984). Many of the prewar collections from Johore (Fig. 4) are from areas that have since been clear-felled but it is still likely to persist on the slopes of hills such as G. Panti. In Trengganu and Kelantan, on the other hand, it has probably increased in abundance since extensive logging of the foothills has taken place. Recent collections show it to be widespread in Trengganu (Sekayu F. R., Ulu Setui F. R., Batu Biwa and Merchang F.R.).

In addition, it has been taken into cultivation. It has also responded well to cryogenic storage (Chin, pers. comm.). So at present its long-term conservation is not under threat.

However, it deserves to be much more widely cultivated. Its dwarf stature, its elegant slender, rosy-purple inflorescences and its white fruits make it an attractive garden plant. Its horticultural potential has yet to be realised.

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