MORPHOLOGY OF JAVANESE SPECIES OF PANDANACEAE

Introduction

The last attempt at a comprehensive treatment of Pandanaceae of Java was Backer and Bakhuizen van den Brink (1968) in their “Flora of Java” in which they recognized seven species of Freycinetia and fifteen species of Pandanus. Since a short visit to Hortus Bogorienses by Stone (1972), there were no further exploration on the pandan flora of the island have been made, thus the pandan flora remains largely unknown.

Since a large number of characters are now known for Freycinetia and Pandanus species, it appears useful to consider their use in identifying plants from Java. The species are invariably classified by the feature of the female for several reasons (Kam 1971). First, the male flowers are very short-lived, generally they bloom and decay within 2 or 3 days. Furthermore, there seem to be a higher percentage of females in any given population. Thirdly, the fruit offers a greater number of useful diagnostic features. The male inflorescences are generally strongly scented, and sometimes offer powering fragrance. The male flowers themselves are simply masses of stamens gathered into units representing branching systems of various ranks. Fieldwork carried out for this study has provided stronger foundation for understanding morphological variation within the species.

Characters of leaf shape, leaf apex, the morphology of leaf auricles and type of pistillate inflorescence were found useful in delimitation and identification of Javanese Freycinetia, while characters of habit, the surface of stem, present or absent of prop root, the surface of prop root, the leaf shape, leaf apex, the armature of leaf margins and midrib, the colour of leaf margin and midrib teeth, the distinctness or indistinctness of tertiary cross vein, present or absent of apical ventral pleats, phalange shapes, the position of infructescence, position of seed chamber and stigma shape are proved useful for distinguishing among species of Javanese Pandanus.
This study was undertaken to have a better understanding on the morphology of the family in order to make a better species delimitation, particularly for species found in Java.

**Materials and Methods**

Morphological study on Javanese species of *Pandanaceae* has been conducted. This study was based mainly on available specimens at the BO, K and L and new collection specimens obtained from field work in different location in Java. In addition, living plants grown in botanical garden were also studied. Five species that was planted in Bogor Botanical Garden, viz. *Pandanus kurzii*, *P. labyrinthicus*, *P. multifurcatus*, *P. polycephalus* and *P. spinistigmaticus* were also examined. The process of undertaking in this study followed the methods described by Rifai (1976) and Vogel (1987).

Basic morphological characters such as habit, stem, leaves, inflorescence, staminate flower, pistillate flower, fruit and their details were used to describe and recognize taxa; all morphological data was used for producing the description of each taxon, while the key to species was constructed from the diagnostic characters only.

The morphological species concept was applied as a framework to define taxa, in which distinction is based on perceived discontinuities in morphological variation (Davis & Heywood 1963).

**Results and Discussion**

**Morphology of Javanese *Freycinetia***

**Habit**

All species of *Freycinetia* found in Java are climber with different size. Three species of *Freycinetia* (*F. imbricata*, *F. javanica* and *F. scandens*) are smallish to medium climber, while *F. insignis* and *F. sumatrana* are medium climbers, and the smallish climber is found in *F. angustifolia*.

The stems are found hanging on trees and branch richly, such as found in *F. angustifolia* and *F. javanica* (Fig. 2.1 A); while in *F. imbricata* the main stem remain adherent to tree trunk, and in some cases makes a complete cover which
makes the trunk of the host tree invisible, such as found in *F. insignis* and *F. sumatrana* (Fig. 2.1 B).

Figure 2.1  Habit of *Freycinetia* spp.: A. *F. javanica*, scale bar = 15 cm  
B. *F. sumatrana*, scale bar = 2 m.

**Stem**

Stems of Javanese *Freycinetia* vary in size, nodes and colour. In term of size, *F. angustifolia*, *F. imbricata*, *F. javanica* and *F. scandens* are included in slender species, while *F. funicularis*, *F. insignis* and *F. sumatrana* are included in robust species. Variation is observed in stem shape. This study showed that *F. angustifolia*, *F. imbricata*, *F. insignis*, *F. scandens*, and *F. sumatrana* had terete stem, whereas *F. javanica* had subterete to terete stem.

Variation is also observed in internode shape. This study showed that *F. angustifolia*, *F. imbricata*, *F. insignis*, *F. javanica*, and *F. sumatrana* had terete internode, whereas *F. scandens* had subterete to terete internode. The surface of the stem can be sulcate or sulcate to canaliculate. The colour also varies from yellowish, greenish brown to reddish brown.

**Leaves**

The leaves of *Freycinetia* are usually green to dark green coloured on the upper surface, but paler green on the lower surface. In Java *F. angustifolia* possesses the smallest and most slender leaves, whereas *F. sumatrana* has the most robust leaves. The leaves arrangement in species of *Freycinetia* found in Java is alternate and imbricate. Four species of *Freycinetia* (*F. angustifolia*, *F.
Funicularis, F. javanica and F. scandens) have alternate leaves, and the other three species (F. imbricata, F. insignis and F. sumatrana) had imbricate leaves.

Leaves are simple blade and usually linear-lanceolate in outline, but variation do exist in some species. F. scandens have variation in leaf shape, from elliptic, oblanceolate to lanceolate. Leaf apex can be abruptly attenuate below the apex to gradually attenuate toward the subulate apex, whereas in F. sumatrana it is long tapering to a slender subulate tip. The margin usually was armed in basal part, apical part and upper midrib of its leaves with serrate prickles. The basal part of F. insignis and F. scandens are denticulate, and basal part of F. sumatrana is dentate. The colour of the prickles may be wholly straw colour or with brown tipped as in F. angustifolia. The laminar part can be chartaceous, subcoriaceous to coriaceous.

**Auricles**

The auricle is an organ of flange-like extensions found on the leaf-sheath, and can be easily seen on the young leaf. Auricles are usually membranous (Fig. 2.2 A), transparent, fragile or coriaceous (Fig.2.2 B). Auricles can be regarded as a good identification character of Freycinetia in the field, because in herbarium specimen they are hardly seen in fine condition. The shape, size, texture, nature of margin, nerves and colour of auricle vary between species. Freycinetia angustifolia possess the smallest auricle, while F. sumatrana possess the biggest auricle. Colour of auricles also varies from pale green in F. insignis to brownish green – brownis yellow in F. javanica.

In Freycinetia, they presented in varying from tapered or rounded to the apex or adnate to the apex. The margin is entire or denticulate to spinulose at apex (F. insignis), or armed almost to the base (F. imbricata). The lamina is usually membranous in F. javanica (Fig. 2.2 A) or coriaceous in F. insignis (Fig. 2.2 B), some of them fragmenting transversally in F. sumatrana or fragmenting laterally in F. scandens, with 4 widely spaced nerved in F. insignis or 1-2 septate in F. javanica.
Auricles type of *Freycinetia* spp.: A. Membranous (*F. javanica*) B. Coriaceous (*F. insignis*). Auricles was shown with arrow. Scale bar = 2 cm

**Bracts**

Bracts are persistence or caduceus, located on the peduncle. Bracts vary in shapes and sizes. Bracts are usually ovate, cymbiform to lanceolate, with entire margin to slightly armed with prickles. The sizes of bracts are in concurrent with their habits. Slender species like *F. angustifolia*, *F. imbricata* and *F. javanica* possess minute bracts, while robust species such as *F. insignis* and *F. sumatrana* have robust bracts as well. Their apex have various shapes, varying according to the species from acute to acuminate in *F. imbricata*, acute to cuspidate in *F. javanica*) mucronate to aristate in *F. angustifolia*, and aristate with aculeate prickles in *F. sumatrana.*

**Peduncle and pedicel**

The peduncle usually is straight and short. The peduncle may be slender or robust, densely or sparsely pubescent or rarely glabrous, only in *F. insignis* the peduncle had bract scar. Usually the pedicell is longer than peduncle. The pedicel shape usually is half-terete, slender (*F. scandens*), usually as thick as peduncle, or only somewhat stouter than the peduncle with 0.2-1.5 cm diameter (*F. insignis*). The surface of pedicels can be glabrous or covered with indumentum. *F. angutifolia*, *F. javanica* and *F. scandens* had glabrous pedicel, while *F. imbricata* and *F. insignis* had puberolous to hirsute pedicell.
Inflorescencia

The inflorescence in most of Freycinetia found in Java are usually located on terminal part of the stems (i.e terminal inflorescence). Lateral inflorescence are less often seen. This study showed that there is one species that possess such feature, viz. F. funicularis. In lateral inflorescence, not only bract that is present, but also prophyll, that is located in the upper part of bracts.

Freycinetia is mostly dioecious, which means that male and female flowers are formed on different plant. Staminate inflorescence is invariably terminal on a normal leafy shoot, usually a raceme of spikes, each of the three or four spikes. Staminate inflorescence are more rarely seen than that of pistillate inflorescence, due to the anthesis which takes only one to three days (Stone 1983b). Similar to other genera of Pandanaceae, Freycinetia identification is therefore mainly based on the structure of female inflorescence and infrutescence.

In Freycinetia, the spikes (both male and female) tend to be closely adjacent and often ternate, so that the open ripe inflorescence seems to be an umbel like in F. javanica (Fig. 2.3 A) or pseudoumbel. In F. angustifolia, the inflorescence is racemiform (Fig. 2.3 B), whereas in F. funicularis, the inflorescence is lateral (Fig. 2.3 C).

Male flowers (Stamen)

The stamens are simple, without branched filaments, and each terminate is in a small rather short anther or sessile stamens, and staminate pedicel is absent.

Female flowers (Pistil)

The pistil consists of multiovulate carpel with carpels separated to base or carpel united. Each carpel tipped by a stigma, and the stigma is sessile. The stigmas vary in number and shape, from 2 to 5 in number, and from ovate (F. javanica), depressed ovate-suborbicular (F. angustifolia, F. imbricata, and F. insignis), pentagonal-suborbicular (F. scandens) or protude (F. funicularis) in shape. The position of the stigma varies from horizontal to sunken in position.
Cephalia

Cephalium (plural: cephalia) is the complex fruit in Pandanaceae. Some of the important morphological character in Freycinetia are found in the cephalia. In the Javanese species of Freycinetia cephalia vary in shapes, size and colours. Four species (F. funicularis F. insignis, F. javanica, and F. sumatrana) have cylindric cephalia. F. angustifolia have cylindric to ob lanceolate cephalia, F. scandens have cylindric to oblong cephalia, and F. imbricata have narrowly elliptic to broadly oblong cephalia. The number of cephalia per inflorescence is usually three, two or four.

Fig. 2.3 Inflorescence type of Freycinetia spp.: A. Umbel (F. javanica), B. Racemiform (F. angustifolia), C. Lateral (F. funicularis). Scale bar = 1 cm
Berries

Berry is the simple fleshy fruit of Freycinetia. In Freycinetia a cephalium consisted of numerous berries. A berry contain many fused ovules, thus a multiovulate fruit, while in Pandanus the simple fruit is always uniovulate. In this circumstances a cephalium can be regarded as a complex fruit. The shape of berries vary from obconic like in F. angustifolia (Fig. 2.4 A) obovate (F. funicularis), oblong (F. javanica) and subpyramidal such as in F. sumatrana. Three species, viz. F. imbricata, F. insignis (Fig. 2.4 B) and F. scandens are the species observed with various shapes of berry from pentagonal to lageniform, pentagonal, lageniform to oblong, and pentagonal, lageniform, ovate to oblong respectively. The apical part of a berry is usually harder and stiffer, while the basal part is usually fleshy.

Fig.2.4 Berries type of Freycinetia spp.: A. Obconic (F. angustifolia) 
B. Lageniform (F. insignis), scale bar = 25 mm

Morphology of Javanese Pandanus

Habit

Unlike Freycinetia that have climbing habit, Pandanus species habit found in Java vary from shrub to tree. Shrub species are P. amaryllifolius (Fig. 2.5 A), P. kurzii, P. nitidus and P. polycaphragal. Tree species include P. bantamensis, P. bidur, P. dubius, P. faviger. P. labyrinthicus, P. leram var. andamanensis, P.
multifurcatus, P. odoratissimus) (Figure 2.4 B), P. pseudolais, P. scabrifolius, P. spinistigmaticus, P. spurius cv Putat, P. tectorius and P. utilis.

Figure 2.5  Habit of Pandanus spp.: A. Shrub (P. amaryllifolius), scale bar = 10 cm; B. Tree (P. odoratissimus), scale bar = 1 m

Stems

Stems of Javanese Pandanus vary in size, colour and branch. Slender stem is found in P. amaryllifolius or short stem in P. kurzii. Erect stem and unbranched are found in P. bantamensis, P. dubius and P. pseudolais, while P. labyrinthicus, P. multifurcatus, P. nitidus, P. odoratissimus and P. spinistigmaticus had spreading branches, whereas P. faviger, P. tectorius var. littoralis and P. utilis had dichotomous branching. Surface of stem can be smooth like P. kurzii, sulcate in P. amaryllifolius, abundant rootlet to thorny in P. bidur, P. dubius, P. labyrinthicus, P. multifurcatus, P. nitidus, P. odoratissimus, P. spinistigmaticus, and P. tectorius var. littoralis or ringed by leaf scars in P. polycephalus and P. utilis. Colour of stem also varies from grey to green or brownish.

Prop root

A prop root is a root formed from the stem, usually close to the ground which helps hold the stem erect and anchor the plant. There are variation in prop root sizes, number and surfaces. Prop root can be small and few in P. amaryllifolius, small and abundant in P. labyrinthicus, P. odoratissimus and P. tectorius var. samak, slender in P. spurius cv Putat (Fig. 2.6 A), some arise from
lateral branches in *P. nitidus* and *P. spurius* cv Putat, long and stout as in *P. bidur*, *P. dubius*, *P. faviger*, *P. leram* var. *andamananum*, *P. multifurcatus*, *P. odoratissimus* (Fig. 2.6 B) and *P. spinistigmaticus* or absent in *P. kurzii* (Fig. 2.6 C). Surface of the prop root can be smooth in *P. scabridolius*, muricate in longitudinal line such as in *P. utilis* (Fig. 2.6 D), *P. tectorius* var. *littoralis*, *P. pseudolais*, and *P. nitidus* or armed with prickles or spine in *P. spinistigmaticus*, *P. polycephalus* and *P. multifurcatus*.

Figure 2.6 Prop root type of *Pandanus* spp.: A. Slender (*P. spurius* cv. Putat); B. Stout (*P. odoratissimus*); C. No prop root (*P. kurzii*); D. Muricate in longitudinal line (*P. utilis*). Scale bar for A = 75 cm, Scale bar for B, C and D = 5 cm.

**Marginal Spine**

Leaves usually set with prickles along its length or part of it. The prickles decrease in size nearing the leaf apex (*P. utilis*, *P. bantamensis*, *P. pseudolais*, *P. tectorius* var. *littoralis*, and *P. nitidus*), always antorse (ascending) but those near leaf base sometimes retrorse, or absent. Their margin are usually prickly,
occasionally entire (*P. spurius* cv. Putat), or prickly very near and at apex only (*P. amaryllifolius*), or occasionally smaller at leaf base, larger at midsection and decreasing in size nearing the leaf apex (*P. bidur, P. dubius, P. odoratissimus*, and *P. scabrefolius*). Twin lateral pleats are often well distinguished, smooth (*P. bantamensis, P. nitidus, P. pseudolais*, and *P. scabrefolius*), or in some species prickly serrate or absent (*P. odoratissimus, P. spinistigmaticus, P. spurius* cv. Putat, and *P. tectorius* var. littoralis). Some species have white spine in *P. tectorius* var. littoralis (Fig. 2.7 A), green prickles with brown tipped (*P. bantamensis, P. pseudolais*, and *P. scabrefolius*) or yellowish green (*P. dubius*) or red prickles in *P. utilis* (Fig. 2.7 B).

**Figure 2.7** Prickles type of *Pandanus* leaves: A. White prickles (*P. tectorius* var. littoralis); B. Red prickles (*P. utilis*), scale bar = 1 cm.

**Leaves**

The leaves of *Pandanus* are usually dark green coloured, glossy and glaucous on upper (adaxial) surface, but paler green on the lower surface, whereas in *P. tectorius* cv. Sanderi have longitudinal of white to pale yellow band from centre to leaf margin. Compared with the other members of *Pandanaceae*, the size of leaf in *Pandanus* is noticeably longer and bigger. In Java *P. amaryllifolius* has the smallest and most slender leaves, whereas *P. pseudolais* possess the longest leaves (299-574.5 cm long). The leave arrangement in all species of *Pandanus* found in Java is spiral. The leaves are simple and usually ensiform to linear in shapes. However variation do exist as in some species, the leaves are observed in ligulate such as found in *P. labyrinthicus, P. multifurcatus, P. odoratissimus* and *P. spurius* cv. Putat. The apical part can be abruptly
terminating in a point to gradually long tapering to subulate apex. Caudate apices are observed only in one species, i.e. *P. dubius*. The margin can be entire as in *P. spurius* cv. Putat or noticeably armed with spines throughout the length, except in *P. amaryllifolius* possess prickles only in the apical part of its leaves. The laminar part can be chartaceous, thin coriaceous, coriaceous to thick coriaceous. Longitudinal lines are more prominent abaxially, with tertiary cross vein on both surfaces. In *P. amaryllifolius*, *P. bantamensis*, *P. bidur*, *P. dubius*, *P. kurzii*, *P. pseudolais*, and *P. scabrilolius* tertiary cross vein form a network of meshes, oblong or rhombic meshes, whereas in *P. leram* var. *andamanensis* tertiary cross vein makes tessellate appearance. The basal part of leaves of *P. kurzii*, *P. polypehalus* and *P. scabrilolius* are whitish, reddish in *P. utilis*, or reddish brown in *P. bantamensis*, and *P. pseudolais*.

**Bracts**

Bract are covering inflorescence and usually formed by the three levels of trichiously arranged bracts. The interior bract covers the inflorescence, while the other two namely exterior and middle bracts protect the interior bract and the inflorescence inside.

Bracts vary in shapes and sizes. Bracts are usually lanceolate in shape, with margins armed with prickles to spines. The sizes of bracts are in concurrent with their habits. Robust species such as *P. bantamensis*, *P. pseudolais* and *P. scabrilolius* have robust bracts as well, while slender species like *P. nitidus* possess slender and minute bracts. The exterior bracts are leaf-like in forms, except in *P. kurzii* the exterior bracts are cymbiform in shape. The inner bracts are shorter and lighter in colour.

The colour of bracts also varies. The colour of exterior and interior bracts can be different. The differences can be seen within the same bract. The colour of the apical part, middle and basal parts may not be uniform such as in *P. odoratissimus*, and in few species the colour of bracts are uniform such as in *P. polypehalus* (white) and *P. utilis* (green). The apex of bracts are observed abruptly acute in *P. utilis*, gradually tapering to a subulate tip in *P. labyrinthicu*, *P. odoratissimus* and *P. tectorius*. 
Inflorescentia

Pandanus are dioecious, which means that male and female flowers are produced on separate plants. The inflorescence in all species of Pandanus in Java is usually found in apical part of the stem (i.e terminal inflorescence). Staminate inflorescences are fragrant and usually pendent, except in P. labyrinthicus staminate inflorescence is erect (Fig. 2.8 A). Staminate inflorescence is also varies in sizes. In P. odoratissimus flowering part of spike is 21.3-33 cm long and bear 9-18 lateral racemes, whereas in P. utilis flowering part of spike is 41-43 cm long and bear 20 lateral racemes (Fig. 2.8 B). Staminate inflorescence are more rarely seen than that pistillate inflorescences, therefore Pandanus identification is mainly based on the structure of female inflorescences and infructescence.

Pistillate inflorescences may be represented by a single cephalium (head) as in P. odoratissimus (Fig. 2.8 C) or by s spike of several cephalia. In P. faviger the pistillate are observed spike of 3 cephalia, whereas in P. polycephalus pistillate inflorescence is raceme of spike (Fig. 2.8 D).

Peduncle

The peduncle is stout and glabrous, generally straight, whereas in P. bantamensis, P. tectorius var. littoralis, and P. utilis they are slightly curved at the end; in P. pseudolais it is curved at the end. Their shapes are usually 3-sided, whereas in P. polycephalus it is obtusely trigonous. Their size is larger at apex and decrease nearing the base. Their colour is varied according to the species from whitish green (P. bantamensis) to green (P. pseudolais, and P. utilis).

Male Flower (Staminate)

The stamens are to be borne in small or large clusters on short or long axes (P. labyrinthicus, P. odoratissimus, P. spurius cv. Putat, P. tectorius var. littoralis, and P. utilis). Most of the male flowers are sessile (Fig. 2.9 A), whereas in P. utilis it is pedicellate (Fig. 2.9 B).
Figure 2.8 Inflorescence type of Pandanus spp.: A. Staminate inflorescence erect (P. labyrinthicus); B. Long staminate inflorescence (P. utilis); C. Pistillate inflorescence in spike (P. odoratissimus); D. Raceme of spikes (P. polycephalus). Scale bar for A and B = 10 cm, scale bar for C and D = 2 cm.

Figure 2.9 Stamen types of Pandanus spp.: A. Sessile (P. tectorius var. littoralis) B. Pedicellate (P. utilis), scale bar = 2 cm
Female Flower (Pistillate)

Female flowers consist of a single uniovulate carpel with a single stigma. The stigma may be sessile as in *P. bidur*, *P. dubius*, *P. odoratissimus*, *P. polycephalus*, *P. tectorius* var. *littoralis*, and *P. utilis* (Fig. 2.10 A) or borne on style in *P. bantamensis*, *P. kurzii*, *P. nitidus*, *P. pseudolais*, and *P. scabrifolius* (Fig. 2.10 B). The stigmas have various shapes, varying according to the species from linear (*P. kurzii*) or rounded (*P. polycephalus*), cordate, elliptic, lanceolate, lip-like (*P. bidur*) or separating in the forkes (*P. bantamensis*, and *P. scabrifolius*).

![Figure 2.10 Stigma type of Pandanus spp.: A. Sessile (*P. utilis*), B. On style (*P. scabrifolius*), scale bar = 1 cm](image)

Cephalia

Some of the important morphological character for species identification in *Pandanus* are in their cephalia (singular, cephalium). In Javanese species of *Pandanus* cephalia vary in shapes, sizes and colours. Five species, i.e. *P. kurzii*, *P. odoratissimus*, *P. scabrifolius*, *P. tectorius* var. *littoralis* and *P. utilis* have subglobose cephalia, while the other species such as in *P. bantamensis*, *P. nitidus*, *P. polycephalus* and *P. pseudolais* possess ellipsoid to oblong cephalia. The number of cephalia per infructescence is usually one, other numbers such as three, five or six are also present but less seen.

In *Pandanus*, a cephalium can be consisted of numerous drupes or phalanges. Drupes is composed of free, a single carpel while phalanges (polydrupes) are carpels that are permanently fused into compound structure. Drupes or phalanges are of great importance in *Pandanu*s classification. The
result of this study showed that seven species, i.e. *P. bantamensis* (Fig. 2.11 A and B), *P. faviger*, *P. kurzii*, *P. nitidus*, *P. polycephalus*, *P. pseudolais* and *P. scabrifolius* have cephalium consisted of numerous drupes, while the other species such as in *P. bidur*, *P. dubius*, *P. leram* var. *andamanensium*, *P. odoratissimus*, *P. tectorius* var. *littoralis* and *P. utilis* (Fig. 2.11 C and D) have cephalia consisted of numerous phalanges. Drupe varies in shape from conical, cuneate to oblongate, while phalange shapes vary from clavate, cuneate, obovate to oblong.

Drupes usually have one stigma while phalanges (polydrupes) have more than one stigma. Some species have sessile stigma, while in other species stigma is on style. The surfaces of cephalium can be smooth, such as in *P. utilis* or covered by flat scales like in *P. kurzii* (Fig. 2.11 E), while in the surface of the apical phalanges of *Pandanus* usually have no cracks on centre apical sinuses, except in *Pandanus tectorius* var. *littoralis*, there are cracks on the centre of apical sinuses on its the surface apical of the phalange (Fig. 2.11F). The apical part of drupe of phalange is usually harder, and the basal part is usually fibrous and fleshy.
Figure 2.11 Cephalia type of *Pandanus* spp.: A. Cephalia consist of numerous drupes (*P. bantamensis*); B. Drupe (*P. bantamensis*); C. Cephalia consist of numerous phalanges (*P. utilis*); D. Phalange (*P. utilis*); E. Cephalia covered by flat scales (*P. kurzii*); F. Apical phalange with cracks on the centre of apical sinuses (*P. tectorius* var. *littoralis*). Scale bar for A and C = 20 cm.; scale for B, D, E and F = 1 cm.
Conclusion