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Leaf morphology and anatomy of 7 varieties of *Ficus deltoidea* (Moraceae)

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Abstract: The extreme morphological variations and unclear boundaries between varieties can lead to the misleading identification of *Ficus deltoidea* Jack (Moraceae) varieties. This has encouraged many taxonomists and botanists to study the variation within *F. deltoidea*. Thus, correct identification of *F. deltoidea* varieties is important, as several morphological and anatomical characters are variety-specific. The present study aims to evaluate the morphology and anatomy of leaf in 7 varieties of *F. deltoidea*, namely var. *deltoidea*, var. *angustifolia*, var. *trengganuensis*, var. *bilobata*, var. *intermedia*, var. *kunstleri*, and var. *motleyana*. It also aims to contribute to the identification of the varieties based on the matured leaf characters. The results reveal varying morphological characters in the type of leaf shape, size, surface texture, margin, midrib dichotomous, and petiole length. Moreover, variations in anatomical characters concerning the structures of the lamina, leaf epidermis, and midrib are also demonstrated.

Key words: *Ficus deltoidea,* leaf, varieties, morphology, anatomy, Moraceae

1. Introduction

Ficus deltoidea Jack (Moraceae), locally known as 'Mas Cotek' among the Malays, is a complex species of subgen. *Ficus*, section *Ficus*, and subsect. *Frutescentiae* Sata (Sata, 1944), which contains more than 25 species available in the Sino-Himalayan and western Malesia regions (Berg, 2003). Among the many species, the most important are the trees with milky latex that contain important ingredients used in traditional medicine and Ayurvedic formulations (Babu et al., 2010). *Ficus deltoidea* is native and widely distributed throughout Malaysia, Thailand, Sumatra, Java, Kalimantan, Sulawesi, and Moluccas (USDA, 2007). The plant is often recognized by its unique syconia (figs), midrib dichotomous, golden dots on the upper surface of the lamina, leafy twigs or periderm not persistent, and milky latex. In Malay traditional medicine, the dried leaves are marketed as an herbal tea. The decoction of the leaves is believed to improve blood circulation and have aphrodisiac activity and antioxidant and antidiabetic properties (Norhaniza et al., 2007; Sulaiman et al., 2008; Adam et al., 2011).

The 7 varieties of *Ficus deltoidea*, namely var. *deltoidea* Corner, var. *angustifolia* (Miq.) Corner, var. *trengganuensis* Corner, var. *bilobata* Corner, var. *intermedia* Corner, var. *kunstleri* (King) Corner, and var. *motleyana* (Miq.) Corner, found in the Malay Peninsula of Malaysia were described by Kochummen (1978). Despite their close morphological similarity, it is argued that several morphological and anatomical characters are variety-specific and useful for varietal identification. Both qualitative and quantitative morphological characters of leaves (shape, length, surface texture, midrib dichotomous, gland densities at the forked midrib, and subsequent dichotomies of the midrib, petiole length, and indumentum densities) and anatomical characters (lamina, leaf epidermis, and midrib) are particularly discriminative. However, the leaf morphology is probably the most variable and shows heterophylly in the species (Nashriyah et al., 2012). The young plants and mature plants of the same variety often display different states of leaf characters. These extreme variations and unclear boundaries between varieties create misleading identifications of *F. deltoidea* varieties.

The anatomy of the leaf was first used for systematic reasons by Duval-Jouve (1875), who stressed the usefulness of epidermal structures in plant taxonomy. The study of the foliar epidermis of *Ficus* L. revealed a number of important anatomical characters that are of taxonomic significance (Sonibare et al., 2006). The epidermis contains 3 main cell types, namely pavement cells, guard cells, and subsidiary cells, which surround the trichomes and stomata. Although the importance of foliar epidermal anatomy for classification has been discussed in detail by

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many authors (Dixon, 2002; Sonibare et al., 2006; Khan et al., 2011; Mavi et al., 2011; Szymura and Wolski, 2011; Ergen Akçin et al., 2013), *F. deltoidea* varieties have not yet been included in any report. Therefore, this study is the first attempt to exhibit interesting leaf anatomy together with morphological characters for identification of 7 *F. deltoidea* varieties, thus providing the basis of interspecific classification of *F. deltoidea*.

2. Materials and methods

2.1. Plant materials

A total 45 accessions of *F. deltoidea* varieties were collected from Malaysia (Table 1). The distribution of *F. deltoidea* varieties based on the samples seen during the course of the study is shown in Figure 1. These samples are currently in cultivation at the Centre for Herbal Germplasm and Taxonomy, Faculty of Agriculture and Biotechnology, Gong Badak Campus, Universiti Sultan Zainal Abidin.

2.2. Morphological study

Quantitative and qualitative morphological data were obtained from the observation of adult plants as measured after each plant set fruits (syconia). We studied the leaf shape, length, surface texture, midrib dichotomous, gland densities at the forked midrib, and subsequent dichotomies of the midrib, petiole length, and indumentum densities.

2.3. Anatomical study

Three plants of each variety, except for var. *motleyana*, which made a total of 19 accessions of *F. deltoidea*, were used for anatomical study. The samples containing leaf tissues were fixed in formalin-acetic acid-alcohol solution for 2 days (Metcalfe, 1960). After removing the fixative by distilled water, they were dehydrated with ethyl alcohol solutions of 30% and 50%. After that, dehydrated specimens were washed with tert-butyl alcohol of increasing dilution series of 60%, 70%, 85%, 95%, and 100% before being embedded into paraffin and sectioned by using a rotary microtome. The sections were stained in a Safranin O/Fast Green combination. The anatomical characters studied were the structures of the lamina, leaf epidermis, and midrib.

3. Results and discussion

3.1. Leaf morphology

The variations in leaf morphology of 7 *F. deltoidea* varieties are shown in Figure 2. All varieties studied showed an alternate leaf arrangement with numerous golden dots on the upper surface of the lamina. The number of waxy glands beneath the lamina was equal to or more than 3. Almost all varieties have a forked midrib, except for var. *intermedia*, which has a mixture of a forked and unforked midrib, and var. *motleyana*, where the midrib was not forked. This explained the exclusion of var. *intermedia* in previous classifications where this variety was transferred to *F. oleifolia* King subsp. *intermedia* (Corner) C.C.Berg (Berg, 2003; Berg and Corner, 2005). Although there was no concrete morphological evidence to support the relationship between var. *intermedia* and var. *motleyana* (Fatihah et al., 2012), the position of var. *intermedia* as a member of the *F. deltoidea* varieties, however, was strongly supported by internal transcribed spacer DNA (Nor-Zuhailah et al., 2010). Further combinations of morphological and molecular study should be employed to confirm the position of this variety.

For var. *bilobata*, var. *trengganuensis*, var. *angustifolia*, and var. *intermedia*, the midrib forked less than 45°, while for var. *deltoidea* and var. *kunstleri*, the midrib forked more than 45°. The leaf apex ranged from rounded in var. *kunstleri*, var. *angustifolia*, and var. *deltoidea* to minutely truncate in var. *trengganuensis*, bilobed in var. *bilobata*, and acuminate in var. *intermedia* and var. *motleyana*. Although these 7 varieties had been previously recorded with a cuneate leaf base (Kochummen and Rusea, 2000; Nashriyah et al., 2012), we found that var. *angustifolia*, var. *intermedia*, and var. *motleyana* showed an acute leaf base while the rest showed an obtuse leaf base. The leaves were generally obovate in shape. However, they were obcordate in var. *bilobata*, spathulate in var. *angustifolia*, and oblanceolate in var. *intermedia* and var. *motleyana*.

The longest leaves were those of var. *motleyana* (11.5–17.0 cm) and the shortest were those of var. *deltoidea* (3.0–3.6 cm). The widest leaves belong to var. *kunstleri* (6.5–8.0 cm) and the narrowest leaves belong to var. *angustifolia* (1.0–2.0 cm). Two general types of leaf margin were observed: wavy in var. *kunstleri*, var. *trengganuensis*, and var. *bilobata*, and entire in var. *angustifolia*, var. *deltoidea*, var. *intermedia*, and var. *motleyana*. There was no previous record reported and further study is needed to identify the leaf margin. The veins were deeply impressed on the lamina surface of var. *kunstleri*, and the other varieties showed a plane or slightly impressed veins. The var. *angustifolia* showed the shortest petiole (0.1–0.4 cm), while the longest petioles belong to var. *kunstleri* and var. *bilobata* (up to 3 cm). This result was in agreement with Nashriyah et al. (2012), who grouped var. *kunstleri*, var. *bilobata*, and var. *trengganuensis* into a long-stalked variety based on their petiole length of >1.0 cm. The description of each variety is summarized in Table 2.

3.2. Leaf anatomy

3.2.1. Lamina

Most studied varieties contain a layer of epidermis at both the adaxial and abaxial leaf surfaces, and 1 to 2 layers of hypodermis at the adaxial leaf surface (Figure 3). The epidermis was formed by only one quadrangular or rounded cell layer. In contrast, the occurrence of multiple layers of epidermis in some *Ficus* species, such as *F. abutilifolia* Miq., *F. platyphylla* Delile, *F. trichopoda*

Table 1. List of samples used in the study.

Variety	Accession no.	Location	Coordinates	Altitude (m)	Collection date
trengganuensis	FD 018	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.912658°, 103.354994°	11.3	18.02.2008
	FD 019	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.913058°, 103.355556°	11.3	18.02.2008
	FD 020	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.913653°, 103.355739°	11.3	18.02.2008
	FD 021	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.914156°, 103.355183°	11.3	18.02.2008
	FD 022	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.912719°, 103.355939°	11.3	18.02.2008
	FD 023	Jambu Bongkok, Ajil, Terengganu, Malaysia	4.912431°, 103.355522°	11.3	14.03.2008
	FD 032	Tembila, Besut, Terengganu, Malaysia	5.742608°, 102.606653°	11.9	23.07.2008
	FD 038	Saujana, Setiu, Terengganu, Malaysia	5.621536°, 102.745436°	6.1	02.11.2008
	FD 039	Saujana, Setiu, Terengganu, Malaysia	5.592591°, 102.664803°	6.1	02.11.2008
	FD 040	Saujana, Setiu, Terengganu, Malaysia	5.617231°, 102.728033°	6.1	02.11.2008
	FD 041	Saujana, Setiu, Terengganu, Malaysia	5.597925°, 102.733800°	6.1	02.11.2008
	FD 042	Saujana, Setiu, Terengganu, Malaysia	5.585483°, 102.753647°	6.1	02.11.2008
	FD 135	Lembah Bidong, Rhu Tapai, Setiu, Terengganu, Malaysia	5.510456°, 102.983144°	10.7	22.12.2008
	FD 145	Lembah Bidong, Rhu Tapai, Setiu, Terengganu, Malaysia	5.505189°, 102.989856°	10.7	22.12.2008
	FD 181	Tapak Semaian, Jabatan Perhutanan, Setiu, Terengganu, Malaysia	5.481178°, 102.796839°	24.7	06.07.2009
kunstleri	FD 031	Bukit Pinang, Laloh, Gua Musang, Kelantan, Malaysia	5.284217°, 102.249789°	53.3	11.06.2008
	FD 034	Laloh, Gua Musang, Kelantan, Malaysia.	5.275761°, 102.251356°	47.5	25.07.2008
	FD 154	Bukit 11, Perak, Malaysia	4.451322°, 100.973306°	38.1	12.03.2009
	FD 170	Pekan, Pahang, Malaysia	3.563256°, 103.368492°	9.1	27.05.2009
angustifolia	FD 074	Guntong, Setiu, Terengganu, Malaysia	5.604544°, 102.726503°	16.5	16.11.2008
	FD 075	Guntong, Setiu, Terengganu, Malaysia	5.609919°, 102.694539°	16.5	16.11.2008
	FD 076	Guntong, Setiu, Terengganu, Malaysia	5.598237°, 102.726646°	16.5	16.11.2008
	FD 151	Bukit 11, Perak, Malaysia	4.463456°, 100.702042°	9.1	12.03.2009
angustifolia	FD 152	Bukit 11, Perak, Malaysia	4.461842°, 100.774503°	15.5	12.03.2009
	FD 153	Bukit 11, Perak, Malaysia	4.429733°, 100.764836°	15.5	12.03.2009
	FD 171	Cameron Highlands, Pahang, Malaysia	4.512525°, 101.479172°	1322.8	27.05.2009
	FD 189	Hutan Lipur Lata Tembakah, Besut, Terengganu, Malaysia	5.591758°, 102.447650°	29.6	07.10.2009
	FD 190	Hutan Lipur Lata Tembakah, Besut, Terengganu, Malaysia	5.588889°, 102.447036°	29.6	07.10.2009
deltoidea	FD 148	Pasir Puteh, Kelantan, Malaysia	5.843469°, 102.397717°	6.1	21.02.2009
	FD 157	Jerantut, Pahang, Malaysia	3.939024°, 102.380880°	70.7	09.04.2009
	FD 158	Jerantut, Pahang, Malaysia	3.948314°, 102.378026°	70.7	09.04.2009
	FD 159	Jerantut, Pahang, Malaysia	3.936327°, 102.397205°	70.7	09.04.2009
	FD 160	Jerantut, Pahang, Malaysia	3.908555°, 102.372290°	70.7	09.04.2009
	FD 161	Jerantut, Pahang, Malaysia	3.953136°, 102.361764°	70.7	09.04.2009
	FD 183	Ajil, Terengganu, Malaysia	4.989750°, 103.067556°	25.6	30.07.2009
	FD 192	Fikri, Setiu, Terengganu, Malaysia	5.637286°, 102.743681°	6.1	07.10.2009
bilobata	FD 013	Pasir Puteh, Kelantan, Malaysia	5.829987°, 102.400584°	4.3	25.01.2008
	FD 014	Pasir Puteh, Kelantan, Malaysia	5.841153°, 102.410078°	4.3	25.01.2008
	FD 175	Cameron Highlands, Pahang, Malaysia	4.512142°, 101.479422°	1322.8	27.06.2009
intermedia	FD 184	Cameron Highlands, Pahang, Malaysia	4.512658°, 101.479294°	1322.8	02.10.2009
	FD 185	Cameron Highlands, Pahang, Malaysia	4.512389°, 101.479486°	1322.8	02.10.2009
	FD 186	Cameron Highlands, Pahang, Malaysia	4.512425°, 101.479428°	1322.8	02.10.2009
	FD 187	Cameron Highlands, Pahang, Malaysia	4.512144°, 101.479414°	1322.8	02.10.2009
	FD 188	Cameron Highlands, Pahang, Malaysia	4.512136°, 101.479375°	1322.8	02.10.2009
motleyana	FD 234	Batu 6 Forest Reserve, Kuching, Sarawak, Malaysia	1.577339°, 110.171856°	14.3	27.01.2011

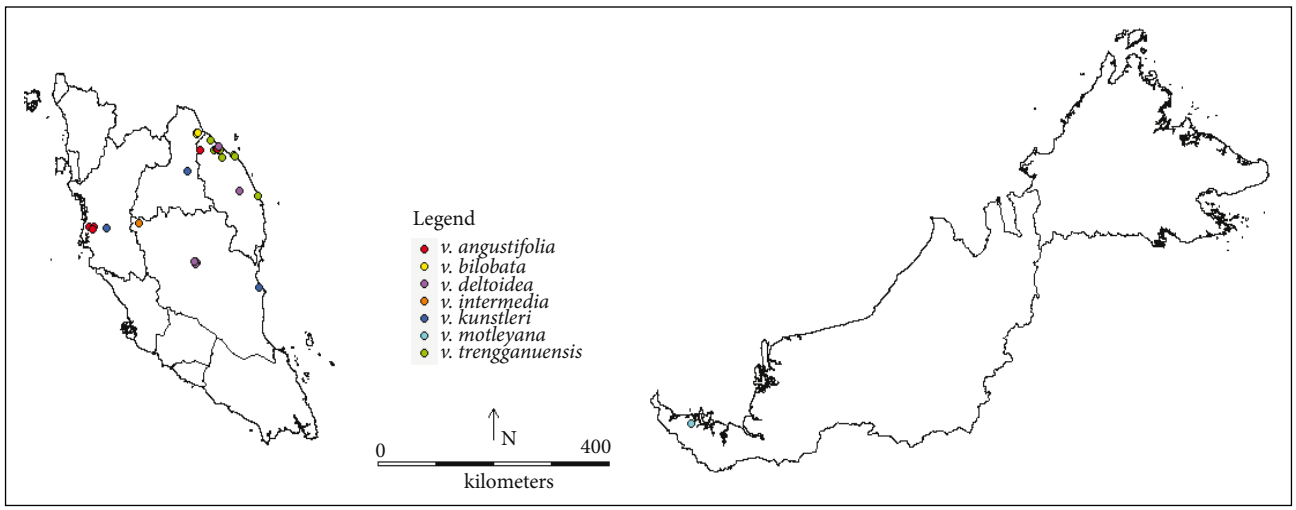

Figure 1. Distribution of the *Ficus deltoidea* varieties collected in Malaysia.

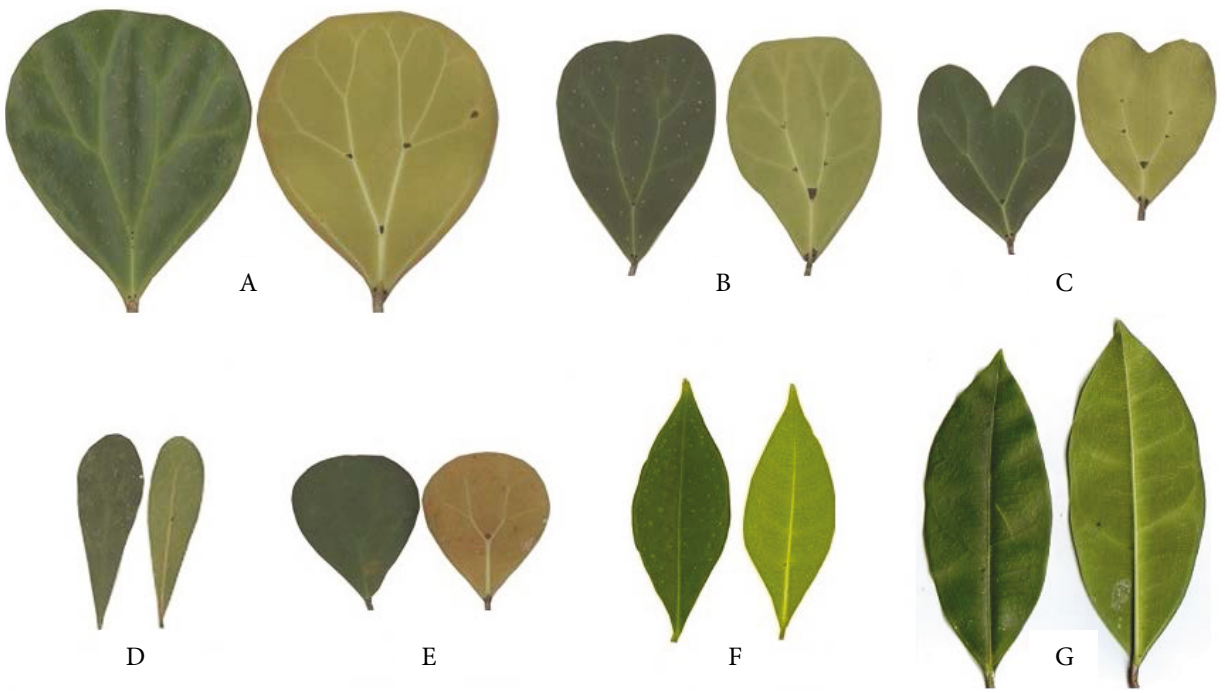

Figure 2. The matured leaf shapes of *Ficus deltoidea*. Pictures showing the adaxial (upper) followed by abaxial (lower) surfaces. A- var. *kunstleri*, B- var. *trengganuensis*, C- var. *bilobata*, D- var. *angustifolia*, E- var. *deltoidea*, F- var. *intermedia*, G- var. *motleyana*.

H.Lév., and *F. elasticoides* De Wild., was described by Sonibare et al. (2006). Cystolith was only found in the epidermal cell at the abaxial leaf surface of var. *motleyana*. A layer of hypodermal cells of equal length was observed in var. *trengganuensis*, while 2 layers of hypodermal cells were only found in var. *deltoidea* and var. *motleyana*. For var. *deltoidea*, the second layer is always longer than the first layer, while for var. *motleyana*, both layers are in equal length. Spongy mesophyll normally occurs in 2 to 4 layers in species like *F. lutea* Vahl, *F. trichopoda* H.Lév., and *F. elastica* Roxb. (Sonibare et al., 2006); however, they were indistinguishable and loosely arranged in var. *kunstleri*, var. *bilobata*, var. *angustifolia*, var. *deltoidea*, var. *intermedia*, and var. *motleyana*. Only var. *trengganuensis* showed an aligned structure of spongy mesophyll.

3.2.2. Midrib

No midrib protrusion was observed on the adaxial leaf surface (Figure 4), although *F. asperifolia* Hook. ex Miq.,

Table 2. The comparison of leaf morphology in 7 *Ficus deltoidea* varieties.

Leaf morphology	Variety						
	kunstleri	*trengganuensis*	*bilobata*	*angustifolia*	*deltoidea*	*intermedia*	*motleyana*
Arrangement	Alternate	Alternate	Alternate	Alternate	Alternate	Alternate	Alternate
Midrib	Forked at the lower third of the lamina	Forked at lower third of the lamina	Forked at or below the middle of the lamina	Forked at or above the middle of the lamina	Forked at lower third of the lamina	Forked near the apex and some not forked	Not forked
Angle of the forked midrib	More than 45°	Less than 45°	Less than 45°	Less than 45°	More than 45°	Less than 45°	Nil
Apex	Rounded	Truncate	Bilobed	Rounded	Rounded	Acuminate	Acuminate
Base	Obtuse	Obtuse	Obtuse	Acute	Obtuse	Acute	Acute
Shape	Obovate	Obovate	Obcordate	Spathulate	Obovate	Oblanceolate	Oblanceolate
Length (cm)	8.0–10.5	6.0–8.5	3.0–4.5	4.0–5.5	3.0–3.6	6.0–7.0	11.5–17.0
Width (cm)	6.5–8.0	3.0–5.0	2.5–4.0	1.0–2.0	2.0–3.5	2.0–4.0	3.2–4.5
Margin	Wavy	Wavy	Wavy	Entire	Entire	Entire	Entire
Surface	Veins deeply impressed	Plane or slightly impressed	Plane or slightly impressed	Plane or slightly impressed	Plane or slightly impressed	Plane or slightly impressed	Plane or slightly impressed
Petiole length (cm)	1.5–3.0	1.0–2.0	1.0–3.0	0.1–0.4	0.4–0.7	0.8–0.95	0.4–0.9

F. exasperata Vahl, *F. mucuso* Welw. ex Ficalho, and a few other species showed a distinct projection (Sonibare et al., 2006). The adaxial surface was flat to concave in most varieties. However, the abaxial surface was curved to nearly flat in some varieties like var. *bilobata*, var. *deltoidea*, var. *intermedia*, and var. *motleyana*, while in var. *kunstleri*, var. *trengganuensis*, and var. *angustifolia*, the abaxial surface was arched to V-shaped. Fibers are usually extended as girders to the adaxial leaf epidermis or hypodermis in *F. saussureana* DC., *F. abutilifolia*, *F. platyphylla*, *F. sagittifolia* Warb. ex Mildbr. & Burret, and *F. ovata* D.Don, but sometimes formed adaxial caps only in some *Ficus* species (Sonibare et al., 2006). Interestingly, fiber cells were formed around the vascular bundle in all *F. deltoidea* varieties under study. The pattern of vascular bundles was used to separate var. *motleyana*, var. *intermedia*, var. *trengganuensis*, and var. *bilobata* from the remaining varieties by having an open-type and continuous vascular bundle while the other varieties have closed-type and separate vascular bundles. The comparison of each variety is summarized in Table 3.

Several previously published classifications of *F. deltoidea* were based on intuitive morphology. The number of varieties fluctuated based on morphological variation and locality (Kochummen, 1998), such as those of Corner (1960), who divided the Southeast Asian species of *F. deltoidea* into 12 varieties and 4 forma, namely var. *deltoidea*, var. *angustifolia* f. *angustissima*, var. *arenaria* Corner, var. *bilobata*, var. *borneensis* Corner f. *subhirsuta* Corner, var. *intermedia*, var. *kunstleri*, var. *lutescens* (Desf.) f. *longipedunculata* Corner, f. *subsessilis* (Miq.) Corner, var. *motleyana*, var. *oligoneura* (Miq.) Corner, var. *peltata* Corner, and var. *trengganuensis*. Later on, a new variety, var. *kinabaluensis* Stapf, which seems to be a synonym of var. *intermedia* of Borneo with larger peduncle and leaves, was introduced (Corner, 1969). In 1978, Kochummen identified 7 varieties, namely var. *deltoidea*, var. *bilobata*, var. *angustifolia*, var. *intermedia*, var. *kunstleri*, var. *motleyana*, and var. *trengganuensis*, which are available in the Malay Peninsula of Malaysia, formerly known as Malaya. After that, 2 endemic varieties of Borneo, namely var. *recurvata* Kochummen with curly margin and var. *subhirsuta* Kochummen with hairs on the surface of the lamina, were added (Kochummen, 1998). Berg (2003) and Berg and Corner (2005) divided the species of the Malesian region into 2 subsp., labeled as subsp. *deltoidea* and subsp. *motleyana*, which seems to be simpler in handling the variation based on the forked and unforked midrib. Recently, Fatihah et al. (2012) supported the later classifications by morphological phylogenetic evidence. Subsp. *deltoidea* contained var. *deltoidea*, var. *bilobata*, var. *angustifolia*, var. *kunstleri*, and var. *trengganuensis*. The second subsp. *motleyana* contained var. *intermedia* and var. *motleyana*. Most authors had their own opinion in discriminating taxa, but the leaf morphology was discussed in almost all reports.

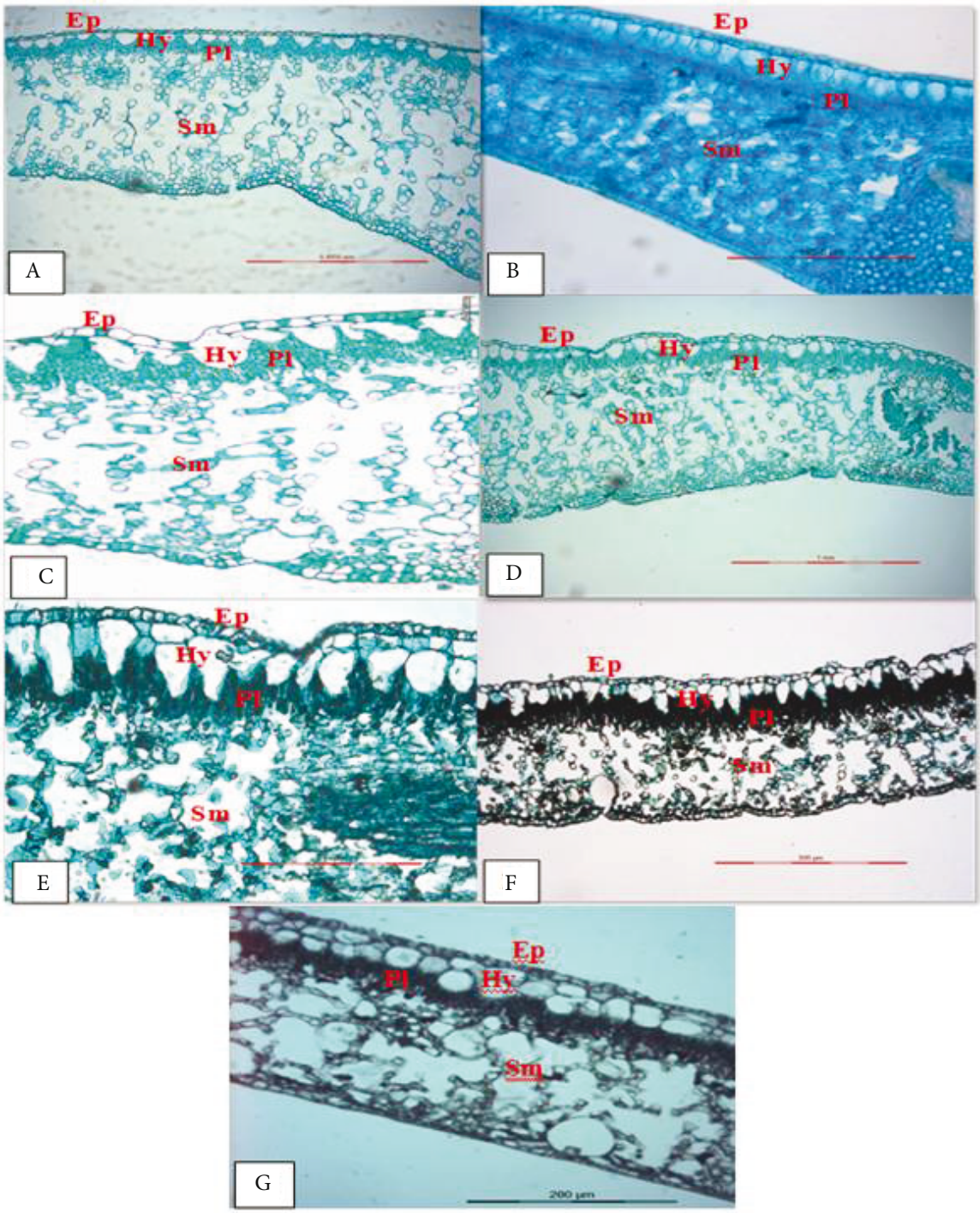

Figure 3. Transverse sections of lamina of *Ficus deltoidea* varieties. A- var. *kunstleri*, B- var. *trengganuensis*, C- var. *bilobata*, D- var. *angustifolia*, E- var. *deltoidea*, F- var. *intermedia*, G- var. *motleyana*. Ep- epidermis, Hy- hypodermis, Pl- palisade cells, Sm- spongy mesophyll.

Observation indicates the taxonomic importance of leaf morphological and anatomical characters employed in the present study. The leaf morphology showed several variations in leaf shape, size, surface texture, margin, midrib dichotomous, and petiole length that can be used to identify the varieties of *F. deltoidea*. Anatomically, variations occurred in the arrangement of spongy mesophyll, the structure of the abaxial surface

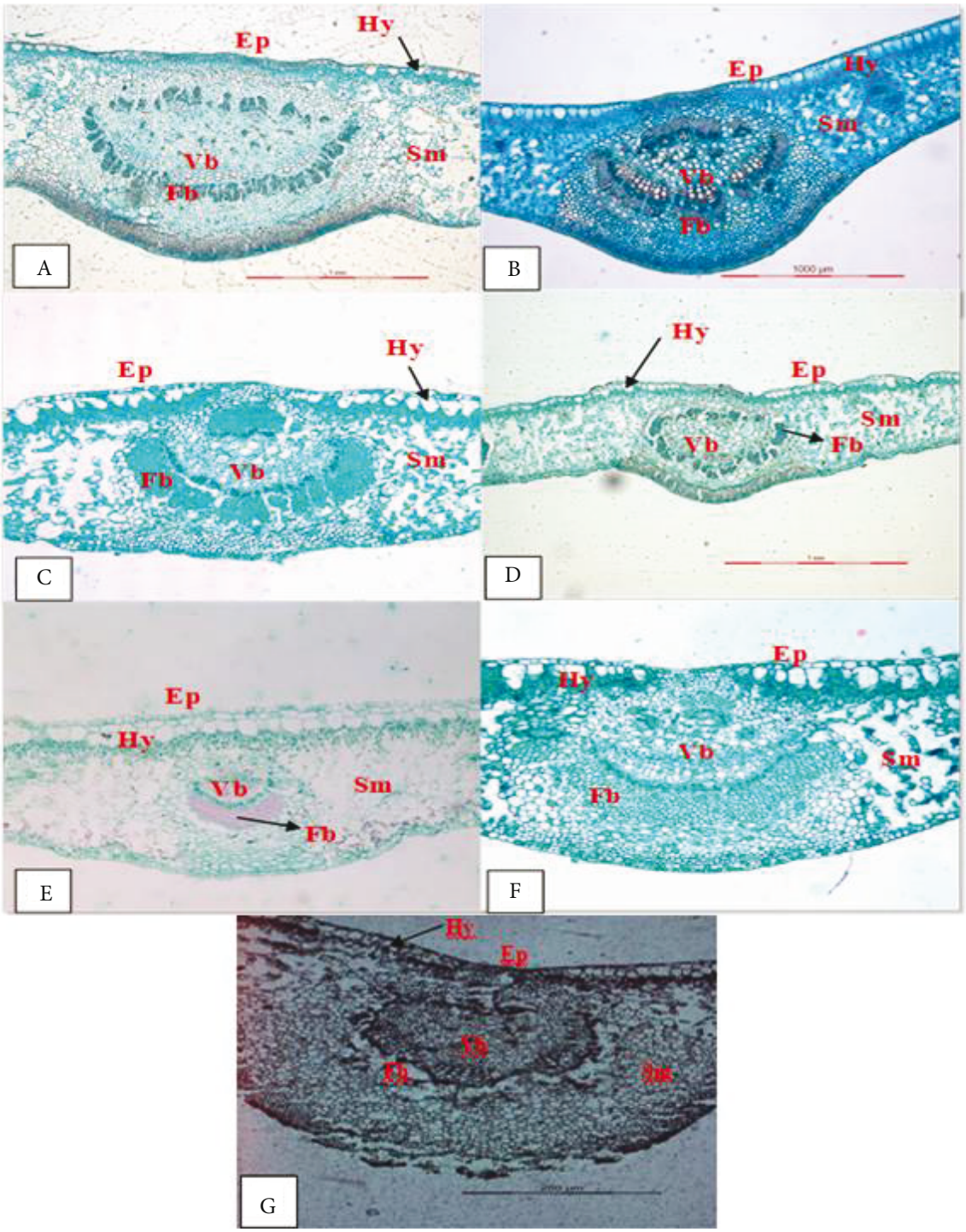

Figure 4. Transverse sections of midrib of *Ficus deltoidea* varieties. A- var. *kunstleri*, B- var. *trengganuensis*, C- var. *bilobata*, D- var. *angustifolia*, E- var. *deltoidea*, F- var. *intermedia*, G- var. *motleyana*. Ep- epidermis, Fb- fibers, Hy- hypodermis, Sm- spongy mesophyll, Vb- vascular bundle.

of midrib, and the pattern of the vascular bundle. These variations were noteworthy and particularly significant to differentiate the varieties of *F. deltoidea*. In addition, there were a few important characters that can be used to discriminate *F. deltoidea* from other *Ficus* species, such as the occurrence of a forked midrib, a single layer of epidermis, 1 to 2 hypodermal layers, and the formation of fiber cells around the vascular bundle.

Table 3. The comparison of selected leaf anatomical features in 7 *Ficus deltoidea* varieties.

Leaf anatomy	Variety						
	kunstleri	*trengganuensis*	*bilobata*	*angustifolia*	*deltoidea*	*intermedia*	*motleyana*
Hypodermis no.	1	1	1	1	2	1	2
Hypodermis length	Unequal	Equal	Unequal	Unequal	Second layer longer than the first layer	Unequal	Equal
Spongy mesophyll arrangement	Loosely arranged	Aligned	Loosely arranged	Loosely arranged	Loosely arranged	Loosely arranged	Loosely arranged
Midrib protrusion	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Midrib adaxial surface	Flat to concave	Flat to concave	Flat to concav	Flat to concave	Flat to concave	Flat to concave	Flat to concave
Midrib abaxial surface	Arched to V-shaped	Arched to V-shaped	Curved and nearly flat	Arched to V-shaped	Curved and nearly flat	Curved and nearly flat	Curved and nearly flat
Pattern of vascular bundle	Closed-type and separated	Open-type and continuous	Open-type and continuous	Closed-type and separated	Closed-type and separated	Open-type and continuous	Open-type and continuous

Many members of the mulberry family (Moraceae) are characterized with the presence of cystolith, such as that found in *F. elastica* (Cutler et al., 2008). The appearance and location of calcium oxalate or calcium carbonate crystals (such as cystolith, a crystal associated with the cell wall) may be specific and useful in plant taxonomic classification (Esau, 1977). In *F. deltoidea* var. *motleyana*, a cystolith was observed (Figure 5) in a cell called a lithocyst (Esau, 1977) in the leaf's lower epidermis. Berg and Corner (2005) reported that cystoliths can only be found on the lower side of leaf lamina in subgen. *Ficus* sect. *Ficus*. That is contrary to recent findings by Awang et al. (2011), who found 5–20 glands or cystoliths on the upper leaf surface of *F. deltoidea* varieties; this was probably due to effects of environment or adaptation to nutrient-poor conditions, as this species is holoepiphytic (Berg and Corner, 2005). Even though *F. deltoidea* produces a white latex, laticifers were not studied in the leaves of *F. deltoidea* varieties because it is doubtful that they have any systematic value (Berg and Corner, 2005). Therefore, issues regarding incomplete sampling (of

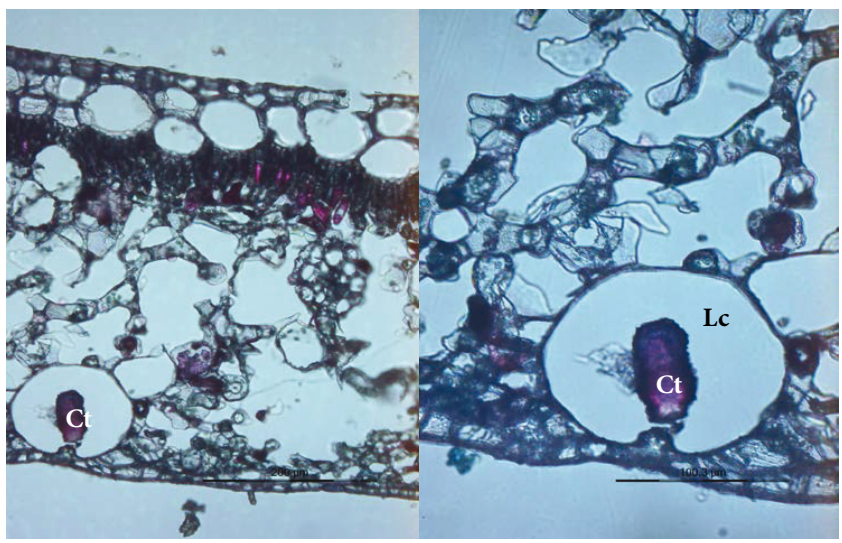

Figure 5. Cystolith present in the leaf lower epidermis of *Ficus deltoidea* var. *motleyana*. Ct- cystolith, Lc- lithocyst.

data and/or taxa) should be taken into account as this can cloud the interpretation of each *F. deltoidea* variety.

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References

Adam Z, Ismail A, Khamis S, Mokhtar MHM, Hamid M (2011). Antihyperglycemic activity of *F. deltoidea* ethanolic extract in normal rats. Sains Malays 40: 5489–5495.

Awang NA, Hasan SMZ, Shafie MS (2011). Evaluation on morphological variability of Mas Cotek (*Ficus deltoidea* Jack) collected in Malaysia. Proceedings of Universiti Malaysia Terengganu 10th International Annual Symposium UMTAS 2011, 11–13 July; Kuala Terengganu, Malaysia.

Babu K, Gokul-Shankar S, Rai S (2010). Comparative pharmacognostic studies on the barks of four *Ficus* species. Turk J Bot 34 : 215–224.

Berg CC (2003). Flora Malesiana precursor for the treatment of Moraceae 3: *Ficus* subgenus *Ficus*. Blumea 48: 529–550.

Berg CC, Corner EJH (2005). Flora Malesiana Series I – Seed Plants: Moraceaea – *Ficus*. Leiden, the Netherlands: Foundation Flora Malesiana.

Corner EJH (1960). Taxonomic notes on *Ficus* Linn., Asia and Australasia. III. Subgen. *Ficus* and section *Ficus*. Gard Bull Singapore 17: 416–441.

Corner EJH (1969). The complex of *Ficus deltoidea*; a recent invasion of the Sunda Shelf. Philos T R Soc Lond 256: 281–317.

Cutler DF, Botha CEJ, Stevenson DW (2008). Plant Anatomy: An Applied Approach. Oxford, UK: Blackwell Publishing.

Dixon DJ (2002). A comparison of the leaf anatomy of *Ficus subpuberula*, *F. atricha* and *F. brachypoda* (Moraceae: *Urostigma* section *Malvanthera*). Nuytsia 15: 27–32.

Duval-Jouve MJ (1875). Histotaxie des feuilles de Gramiees. Ann Sci Nat Bot Paris Ser 6: 227–346 (in French).

Ergen Akçin Ö, Şenel G, Akçin Y (2013). Leaf epidermis morphology of some *Onosma* (Boraginaceae) species from Turkey. Turk J Bot 37: 55–64.

Esau K (1977). Anatomy of Seed Plants. 2nd ed. New York, NY, USA: John Wiley & Sons.

Fatihah HNN, Nashriyah M, Zaimah ARN, Zuhailah MN, Norhaslinda H, Khairil M, Ghani AY, Ali AM (2012). Morphological phylogenetic analysis of seven varieties of *Ficus deltoidea* Jack from the Malay Peninsula of Malaysia. PLoS One 7: e52441.

Khan KY, Khan MA, Ahmad M, Shah GM, Zafar M, Niamat R, Munir M, Abbasi AM, Fazal H, Mazari P et al. (2011). Foliar epidermal anatomy of some ethnobotanically important species of genus *Ficus* Linn. J Med Plants Res 5: 1627–1638.

Kochummen KM, Rusea G (2000). Moraceae. Tree Flora of Sabah and Sarawak 3: 181–334.

Kochummen KM (1978). Moraceae. In: Ng FSP, editor. Tree Flora of Malaya (A Manual of Foresters), Vol. 3. Petaling Jaya, Malaysia: Longman Malaysia Sdn. Bhd., pp. 119–168.

Kochummen KM (1998). New species and varieties of Moraceae from Malaysia. Gard Bull Singapore 50: 197–219.

Mavi DÖ, Doğan M, Cabi E (2011). Comparative leaf anatomy of the genus *Hordeum* L. (Poaceae). Turk J Bot 35: 357–368.

Metcalfe CR (1960). Anatomy of Monocotyledons. I. Gramineae. Oxford, UK: Clarendon Press.

Nashriyah M, Nurrul Akmar R, Nor Zaimah AR, Norhaslinda H, Zanariah MN, Nur Fatihah HN, Yunus AG, Ali AM (2012). Leaf morphological variations and heterophylly in *Ficus deltoidea* Jack (Moraceae). Sains Malays 41: 527–538.

Norhaniza A, Sin CY, Chee ES, Nee KI, Renxin L (2007). Blood glucose lowering effect of *Ficus deltoidea* aqueous extract. Malays J Sci 26: 73–78.

Nor-Zuhailah M, Ali AM, Nashriyah M, Choong CY (2010). Molecular phylogeny of *Ficus deltoidea* Jack from internal transcribed spacer (ITS). Proceedings of the 11th Symposium of the Malaysian Society of Applied Biology, 13–15 June; Kota Bharu, Kelantan, Malaysia.

Sata T (1944). A monographic study of the genus *Ficus* from the point of view of economic botany. Contr Hort Inst Taihoku Imp Univ 32: 1–405.

Sonibare MA, Jayeola AA, Egunyomi A (2006). Comparative leaf anatomy of *Ficus* Linn. species (Moraceae) from Nigeria. J Appl Sci 6: 3016–3025.

Sulaiman MR, Hussain MK, Zakaria ZA, Somchit MN, Moin S, Mohamad AS, Israf DA (2008). Evaluation of the antinociceptive activity of *Ficus deltoidea* aqueous extract. Fitoterapia 79: 557–561.

Szymura M, Wolski K (2011). Leaf epidermis traits as tools to identify *Solidago* L. taxa in Poland. Acta Biol Cracov Bot 53: 38–46.

USDA (2007). ARS, National Genetic Resources Program, Germplasm Resources Information Network – (GRIN) Database. Beltsville, MD, USA: National Germplasm Resources Laboratory. [accessed 14 June 2010].