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Leaf Morphological Variations and Heterophylly in *Ficus deltoidea* Jack (Moraceae)

(Variasi Morfologi dan Heterofili Daun dalam *Ficus deltoidea* Jack (Moraceae))

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ABSTRACT

Six varieties of Ficus deltoidea *Jack (Moraceae) showed leaf morphological variations through quantitative measurement on different plant parts. There were significant differences among six varieties studied by plant parts. The varieties studied include var.* deltoidea *Corner, var.* angustifolia *(Miq.) Corner, var.* trengganuensis *Corner, var.* bilobata *Corner, var.* intermedia *Corner, and var.* kunstleri *(King) Corner. The upper, middle and lower plant parts showed morphological variations in terms of leaf length, leaf width, leaf area and petiole length. Qualitative parameters also showed trends in morphological variations in terms of leaf shape, leaf base, leaf apex and leaf attachment. However, some qualitative parameters were not the recommended parameters to differentiate among varieties. On the other hand, leaf heterophylly has occurred in* F. deltoidea *because foliage of the young plant was different from the mature plant. Leaf heterophylly was observed in leaf shape and leaf apex parameters, whereby leaves from the lower plant parts were different from the upper and middle parts. The heterophylly in leaf shape was detected in varieties* angustifolia, bilobata, intermedia *and* trengganuensis, *whilst six varieties of* F. deltoidea *showed leaf apex heterophylly.*

Keywords: Ficus deltoidea *Jack; leaf heterophylly; leaf morphological variations; plant parts; variety*

ABSTRAK

Enam varieti Ficus deltoidea *Jack (Moraceae) telah menunjukkan pelbagai variasi morfologi daun melalui ukuran kuantitatif pada bahagian pokok yang berlainan. Terdapat perbezaan yang signifikan di antara enam varieti yang dikaji berdasarkan bahagian pokok yang berbeza. Varieti yang yang dikaji termasuklah var.* deltoidea *Corner, var.* angustifolia *(Miq.) Corner, var.* trengganuensis *Corner, var.* bilobata *Corner, var.* intermedia *Corner, dan var. kunstleri (King) Corner. Bahagian atas, tengah dan bawah pokok menunjukkan pelbagai variasi morfologi dari segi panjang daun, lebar daun, luas permukaan daun dan panjang petiol. Parameter kualitatif juga menunjukkan tren dalam variasi morfologi dari segi bentuk daun, bentuk dasar daun, puncak daun dan lampiran daun. Walau bagaimanapun, beberapa parameter kualitatif tidak disyorkan untuk membezakan varieti-varieti berkenaan. Sebaliknya, terdapat heterofili daun pada* F. deltoidea *kerana dedaun tumbuhan muda berbeza dari pokok yang matang. Heterofili daun diperhatikan pada bentuk daun dan parameter puncak daun, di mana daun dari bahagian pokok yang lebih bawah adalah berbeza dari bahagian-bahagian atas dan tengah. Heterofili dalam bentuk daun dikesan dalam varieti* angustifolia, bilobata, intermedia *dan* trengganuensis, *manakala enam varieti F. deltoidea menunjukkan heterofili pada puncak daun.*

Kata kunci: Bahagian pokok; Ficus deltoidea *Jack*; *heterofili daun; variasi morfologi daun; varieti*

INTRODUCTION

Figs or *Ficus* plants originated in Asia Minor and can be found throughout Mediterranean, Indian subcontinent, Latin America, Texas, Southern California, until the far east such as in the Malesian tropical rain forest; with about 750 species. It is one of the largest genera of flowering plants with six traditional subgenera that are recognized based on morphology and distribution (Lansky & Paavilainen 2011).

Succesful spreading worldwide give way to specification due to diverse natural habitats. *Ficus deltoidea* or mistletoe fig is a native of Peninsular Malaysia and introduced elsewhere. It is distributed in Malesia that include Thailand, Indonesia and Malaysia (Lansky & Paavilainen 2011). There are fine spots with gold colour on the surface of each leaves and the vernacular name of *Mas cotek* is given in Peninsular Malaysia because of it. Other vernacular names include *sempit-sempit* and *agoluran* for people in Sabah, Sarawak and Kalimantan Islands and *tabat barito* for Indonesians (Desaku 2005). *Ficus deltoidea* is recognized for health benefits and medicinal values. Its leaves have the distinct characteristics

of human reproductive organs and thus used particularly for the female and male fertility treatments. Traditionally, decoction of the leaves are taken by female after childbirth to constrict the womb, to improve blood circulation and to treat problem of menstrual cycle (Sulaiman et al. 2008). This plant also helps to assist the effectiveness of vitamin C in controlling nitric oxide and blood circulation (Desaku 2005).

The habit of *Ficus* plants is usually bushy or shrubby forms with leaves arranged in spiral and ascending twigs. *F. deltoidea* var. *deltoidea* and var. *kunstleri* are primarily epiphytes whereas var. *trengganuensis* is primarily terrestrial similar to var. *motleyana*. The var. *motleyana* may grow up as a spindly tree reaching 6 m high whereas var. *angustifolia* is the undergrowth shrub (Corner 1969).

Ficus deltoidea is commonly found in Peninsular Malaysia; generally as an epiphyte in lowlands and mountains but also as a terrestrial shrub on sandy shores, mountain tops and in bogs (Starr et al. 2003). The majority of varieties grow at below 1200 m altitude, however *F. deltoidea* var. *intermedia* can be found in the higher mountain areas above the dipterocarp forest. *Ficus deltoidea* var. *angustifolia* grows in places by the streams or riversides. In Borneo, the var. *motleyana* is found in the coastal, peat-swamp and sandy heath forests (Corner, 1969).

The leaf shape is variable in the entire genus, and ranges from elliptical or lanceolate to obovate or spathulate. The leathery leaves of *F. deltoidea* are broadly spoon-shaped to obovate, with the leaf length between 4 cm and 8 cm long, bright-green colored above and rust-red to olive-brown beneath. Figs are from spherical to round-shaped, width to 1.5 cm across, ripening from dull-yellow to orange and red and are freely produced in pairs (Starr et al. 2003). Laman and Weiblen (1998) reported that the fig shape is globose with rounded or umbonate apex. Fig size ranges from 0.5 cm to 0.9 cm long and 0.5 cm to 0.8 cm wide. The colour of fig is from green to yellow and orange when ripening.

The leaf morphology is a traditional character which had been developed with an accepted system for describing the leaf form. This approach has been used in overcoming taxonomic controversies (Jasper et al. 2006). However, many leaf morphological data were not available from the published literatures as represented by both Tables 1 and 2.

Kochummen and Rusea (2000) reported that the leaf shapes of *Ficus deltoidea* are highly variable which include deltoid, elliptic, obovate, spathulate or rhomboid. Furthermore, confusing variations in the leaf morphology also involved dimension, shape, venation, presence and distribution of waxy glands and length of petiole. The shapes of leaf's lamina are oblong, elliptic, obtriangular, oblanceolate, spathulate, linear and suborbicular (Berg & Corner 2005). Thus the leaf morphology of *Ficus deltoidea* is very diverse in nature and requires further study for the ease of visual plant identification and commercialization.

Ficus deltoidea is known as a variable species with 15 recognized varieties and eight of the varieties occur in Sabah and Sarawak (Kochummen & Rusea 2000). Turner (1995) reported the seven varieties of *Ficus deltoidea*; namely var. *deltoidea*, var. *angustifolia*,var. *trengganuensis*, var. *bilobata*, var. *intermedia*, var. *kunstleri* and var. *motleyana*. However, current study was carried out on six varieties only due to unavailability of *Ficus deltoidea* var. *motleyana* in the Germplasm Living Collection at the Gong Badak Campus of Universiti Sultan Zainal Abidin or elsewhere known in Peninsular Malaysia, at the time of this study.

Heterophylly is defined as the occurrence of different types or more than one types of leaf on the same plant. Leaf heterophylly was expected because some varieties showed variability in leaf shape between mature and young plants. The aims of this study were to determine the quantitative and qualitative leaf morphological variations in six varieties of *F. deltoidea* at the lower, middle and upper plant parts; and to observe the occurrence of leaf heterophylly in six varieties of *F. deltoidea*.

TABLE 1. Quantitative parameters of *Ficus deltoidea* varieties

Variety	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)
angustifolia	2.3 - 3.0 (Corner 1960)	0.5 - 1.0 (Corner 1960)	0.3 - 10.0 (Corner 1960)
deltoidea	3.0 - 5.0 (Laman & Weiblen 1998)	3.0 - 4.0 (Laman & Weiblen 1998)	NA
bilobata	2.0 - 7.0 Corner 1960)	1.0 - 3.5 (Corner 1960)	0.3 – 2.5 (Corner 1969)
intermedia	3.0 - 10.0 (Kochummen & Rusea 2000)	1.5 - 5.5 (Kochummen & Rusea 2000)	0.2 – 1.5 (Corner 1960)
trengganuensis	2.3 - 8.0 (Corner 1960)	1.5 -5.5 (Corner 1960)	1.0 – 5.0 (Corner 1960)
kunstleri	6.0 – 14.0 (Corner 1969)	5.0 - 14.0 (Corner 1969)	1.3 - 9.0 (Corner 1969)

*NA, not available

TABLE 2. Qualitative parameters of *Ficus deltoidea* varieties

Variety	Leaf attachment	Leaf shape	Leaf base	Leaf apex
angustifolia	NA	Spathulate or lanceolate obovate (Corner 1969)	NA	Rounded to obtuse (Berg & Corner 2005)
deltoidea	NA	Deltoid (Kochummen & Rusea 2000)	NA	NA
bilobata	Long - petiolate (Corner 1969)	Spathulate, obovate or obdeltoid (Corner 1969)	NA	Shortly bilobed (Corner 1969)
intermedia	Long -petiolate Short - petiolate (Corner 1969)	Elliptic to spathulate (Kochummen & Rusea 2000)	Cuneate (Kochummen & Rusea 2000)	Obtuse (Kochummen & Rusea 2000)
trengganuensis	Long - petiolate (Corner 1969)	Elliptic to rounded obovate (Corner 1969)	NA	NA
kunstleri	Long - petiolate (Corner 1969)	Obtriangular to obovate (Berg & Corner 2005)	NA	Obtuse to truncate (Berg & Corner 2005)

*NA, not available

MATERIALS AND METHODS

The qualitative and quantitative parameter measurements were taken for each plant parts; namely upper, middle and lower. The upper part measurement of *Ficus deltoidea* was taken at the first sampling, middle part measurement was taken at the second sampling and lower part measurement was taken at the third sampling. Each sampling was taken monthly which started from August to October 2009.

The leaf morphological variation was expected to show the differences along the sampling months either qualitatively or quantitatively in *Ficus deltoidea* varieties. The qualitative measurement was obtained by observation on the leaf morphology. Observation on the leaf morphology was in terms of leaf shape, leaf attachment, leaf apex and leaf base (Simpson 2006; Wilde et al. 1972). The leaf quantitative parameters measured were leaf length, leaf width, petiole length and leaf area. *Ficus deltoidea* has a simple leaf, thus leaf length was measured in centimeters from the base of the blade to the apex. Leaf width was measured across the blade at its widest point. The petiole length was measured in centimeters from the base of the leaf blade to the point of attachment to the stem. These external leaf characters were measured in centimeters by using a ruler whereas the leaf area was measured by using the graph paper.

The leaves were measured from the number four downwards from the youngest branch. The same leaves from quantitative measurement were used for qualitative measurement. Ten samples were observed from one plant per variety per observation and three plants were used, which represented three replicates of each *F. deltoidea* variety.

The data analysis of *Ficus* in both qualitative and quantitative parameters measured was carried out by using the SPSS software. The significant differences for quantitative measurement between sampling within varieties of *F. deltoidea* was determined by using two-way ANOVA (Repeated Measurement). Repeated measurement was used because the data was taken repeatedly from August to October 2009. The ϱ value (significant) of leaf length, leaf width, petiole length and leaf area shown were either less or similar (≤) than/to alpha (α), which is 0.05.

Qualitative measurement was analyzed to know the trend of six varieties of *Ficus deltoidea*. The data was analyzed by using crosstab from the SPSS software.

The previous researchers have been using the herbarium collection as a guide to identify the common occurrences or rareness of the *Ficus deltoidea* varieties (Corner, 1969) whereas this study used only the living plant collection.

RESULTS AND DISCUSSION

The synonyms of *Ficus deltoidea* is *Ficus diversifolia* Blume (Kochummen & Rusea 2000) indicating the foliar variability or "diverseness". However, the main character of *F. deltoidea* is spathulate leaf shape with a branching midrib (Laman & Weiblen 1998).

QUANTITATIVE MEASUREMENTS
LEAF LENGTH

The total plant means of leaf length for var. *deltoidea,* var. *angustifolia,* var. *kunstleri,* var. *bilobata,* var. *trengganuensis* and var. *intermedia* are as shown in Figure 1.

The significant test of 95% CI showed that the leaf length for var. *deltoidea,* var. *angustifolia,* var. *kunstleri,*

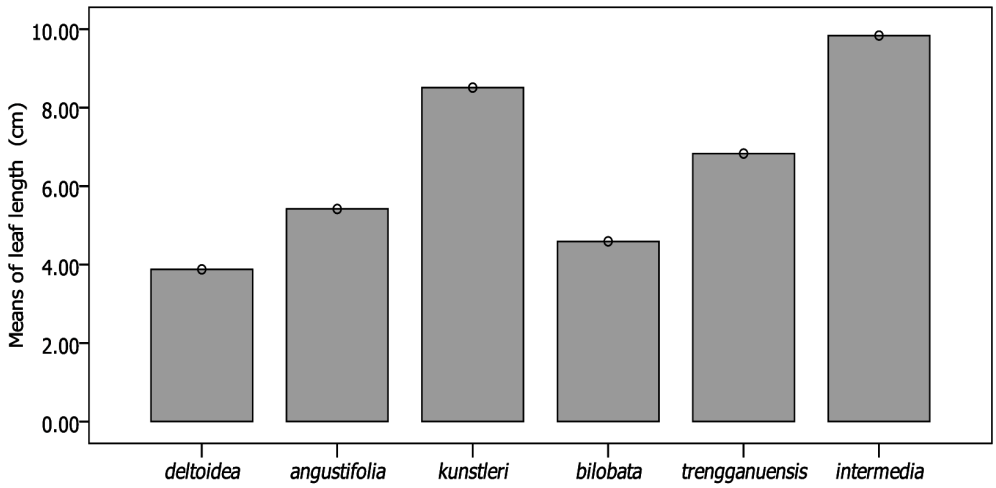

FIGURE 1. The total plant means of leaf length between varieties

TABLE 3. Comparison of leaf length for *Ficus deltoidea* variety by plant parts

Variety	Plant parts	Leaf length (cm) (Mean ± SE)	Test of significant (95% CI)
deltoidea	Upper	3.8 ± 0.3	*
	Middle	3.9 ± 0.2	*
	Lower	3.9 ± 0.2	*
angustifolia	Upper	5.6 ± 0.3	*
	Middle	5.4 ± 0.2	*
	Lower	5.3 ± 0.2	*
kunstleri	Upper	8.9 ± 0.3	*
	Middle	8.3 ± 0.2	*
	Lower	8.3 ± 0.2	*
bilobata	Upper	5.5 ± 0.3	*
	Middle	4.2 ± 0.2	*
	Lower	4.1 ± 0.2	*
trengganuensis	Upper	6.6 ± 0.3	*
	Middle	7.0 ± 0.2	*
	Lower	6.9 ± 0.2	*
intermedia	Upper	10.2 ± 0.3	*
	Middle	9.7 ± 0.2	*
	Lower	9.6 ± 0.2	*

Note:*Significant at 0.05, where 0 was outside 95% CI

var. *bilobata*, var. *trengganuensis* and var. *intermedia* were significantly different either by between varieties or by plant parts (Table 3).

The total plant means of leaf lengths between varieties (Figure 1) were different from the means of leaf length between plant parts (Table 3), and ranges between 3.8 cm and 10.2 cm for the upper part, 3.9 cm and 9.7 cm for the middle part and 3.9 cm and 9.6 cm for the lower part. The longest leaf was from var. *intermedia* which was 10.2 cm at the upper part of plant, whilst the shortest leaf was from var. *deltoidea* with mean of 3.8 cm at the upper plant part (Table 3).

The leaf length of var. *deltoidea* ranged from 3.8 cm to 3.9 cm and was different from the previous work which

was from 3.0 cm to 5.0 cm (Laman & Weiblen 1998) but the measured leaf length was within the range. The leaf length of var. *intermedia* was also different from previous work (Laman & Weiblen 1998) where it ranged from 9.6 cm to 10.2 cm (Table 3). However, the leaf length measured in this study for var. *intermedia* was still within the range as measured by Corner in 1969 that are between 3.0 cm and 10.0 cm (Kochummen & Rusea 2000).

Other than that, var. *angustifolia*, var. *bilobata*, var. *trengganuensis,* var. *kunstleri* and var. *intermedia* also showed differences in leaf length (Table 3) as compared to previous works (Table 1). These differences could be because most of the previous researchers have been studying the herbarium collections as their sample (Corner 1969) whereas in this study the samples were the living plant collections.

Based on Figure 1 and Table 3, var. *intermedia* has the longest leaf as compared to other varieties whereas the shortest leaf was measured from var. *deltoidea*. Based on all three plant parts studied, var. *intermedia,* var. *kunstleri* and var. *trengganuensis* have means of leaf length above 6.0 cm; whereas var. *angustifolia*, var. *bilobata* and var. *deltoidea* have means of leaf length below 6.0 cm in all plant parts.

Other than that var. *intermedia,* var. *kunstleri,* var. *angustifolia* and var. *bilobata* showed longer leaf lengths at the upper plant part as compared to other parts. Whilst for var. *trengganuensis* and var. *deltoidea*, they have the smallest leaf lengths at the upper part of plants.

The leaf length of the upper part of var. *bilobata* was approximately similar to var. *angustifolia* at all parts. The leaf length of the lower part of var. *bilobata* was also approximately similar to var. *deltoidea* at both the middle and lower plant parts. Due to this overlapping data, the leaf length is not recommended as the character to differentiate between the var. *angustifolia* and var. *bilobata* as well as between var. *bilobata* and var. *deltoidea*.

LEAF WIDTH

The total plant means of leaf width for var. *deltoidea,* var. *angustifolia,* var. *kunstleri,* var. *bilobata,* var. *trengganuensis* and var. *intermedia* (Figure 2). The widest leaf width was measured in var. *kunstleri* at 7.8 cm whilst the smallest leaf width at 1.9 cm was shown by var. *angustifolia*. The total plant means of leaf width for var. *intermedia* was at 5.2 cm and var. *deltoidea* was at 3.0 cm. Both var. *bilobata* (4.0 cm) and var. *trengganuensis* (4.0 cm) had similar total plant means of leaf width (Figure 2).

Table 4 shows means of leaf width for six varieties of *Ficus deltoidea* based on three parts of plant; upper, middle and lower. At the upper part of plant, the widest leaf was from var. *kunstleri* with the mean of 8.1 cm whilst var. *angustifolia* had the narrowest leaf width with the mean of 1.8 cm. These results were similar with the previous works (Table 1) that indicated var. *kunstleri* has the widest leaf (5.0 cm - 14.0 cm) and var. *angustifolia* has the narrowest leaf width (0.5 cm - 1.0 cm).

Based on Table 4, the means of leaf width for all varieties were different by each plant parts. The range of leaf width for upper part was 1.8 cm - 8.1 cm, for middle plant part was 2.0 cm - 7.7 cm, and 1.9 cm - 7.7 cm for the lower part. *Ficus deltoidea* var. *trengganuensis* showed the widest leaf width at the middle plant part (4.1 cm) compared to the upper (3.8 cm) and lower (4.0 cm) parts of plant. While the widest leaf for var. *bilobata* was at the lower part (4.2 cm) compared to upper (4.2 cm) and middle (4.0 cm) parts of plant.

Each plant parts showed different means of leaf width within varieties. However, there was similar leaf width between var. *bilobata* at the upper part with *trengganuensis* variety at the lower part which was 4.0 cm (Table 4).

Based on previous works (Table 1), the leaf width of var. *intermedia* and var. *trengganuensis* were similar which range from 1.5 cm - 5.5 cm. However in this study,

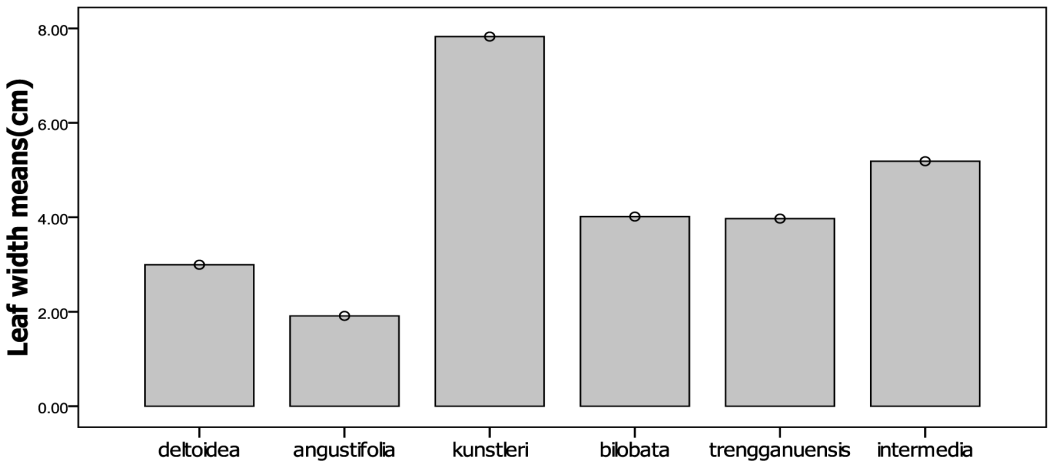

FIGURE 2. The total plant means of leaf width between varieties

TABLE 4. Comparison of leaf width for *Ficus deltoidea* variety by plant parts

Variety	Plant parts	Leaf width (cm) (Mean ± SE)	Test of significant (95% CI)
deltoidea	Upper	2.9 ± 0.2	*
	Middle	3.1 ± 0.1	*
	Lower	3.0 ± 0.2	*
angustifolia	Upper	1.8 ± 0.2	*
	Middle	2.0 ± 0.1	*
	Lower	1.9 ± 0.2	*
kunstleri	Upper	8.1 ± 0.2	*
	Middle	7.7 ± 0.2	*
	Lower	7.7 ± 0.1	*
bilobata	Upper	4.0 ± 0.2	*
	Middle	3.8 ± 0.1	*
	Lower	4.2 ± 0.2	*
trengganuensis	Upper	3.9 ± 0.2	*
	Middle	4.1 ± 0.1	*
	Lower	4.0 ± 0.2	*
intermedia	Upper	5.5 ± 0.2	*
	Middle	5.0 ± 0.1	*
	Lower	5.1 ± 0.2	*

Note:* Significant at 0.05, 0 outside 95% CI. NS at 0.05, 0 with 95% CI

the leaf width of var. *intermedia* ranged from 5.0 cm - 5.5 cm whilst of var. *trengganuensis* ranged from 3.8 cm - 4.1 cm. The reason for these differences was probably because var. *deltoidea,* var. *angustifolia,* var. *bilobata,* var. *kunstleri* and var. *trengganuensis* leaves were sampled at the nursery whilst the leaves of protected var. *intermedia* were sampled *in situ* at Gunung Brinchang.

Table 4 shows that var. *kunstleri* and var. *intermedia* have wider means of leaf width at the upper plant parts as compared with var. *trengganuensis*, var. *bilobata*, var. *deltoidea* and var. *angustifolia*. For var. *trengganuensis* and var. *bilobata,* they have approximately similar leaf widths at the upper and lower parts of plant. The total plant means of leaf width were also similar at 4.0 cm (Figure 2), thus leaf width is not recommended as the character to differentiate between the var. *trengganuensis* and var. *bilobata*.

PETIOLE LENGTH

The total plant means of petiole length for var. *deltoidea,* var. *angustifolia,* var. *kunstleri,* var. *bilobata,* var. *trengganuensis* and var. *intermedia* were as shown in Figure 3. Variety *kunstleri*, var. *bilobata*, var. *trengganuensis* and var. *intermedia* have the total plant means of petiole length of above 1.0 cm whereas var. *deltoidea* and var. *angustifolia* have the total plant means of petiole length of below 1.0 cm (Figure 3).

Ficus deltoidea var. *bilobata* has the longest mean of petiole length at the upper plant part whilst var. *kunstleri* has the longest mean of petiole length at the middle and lower parts of plant. The mean of petiole length for var. *kunstleri* was not more than 4.0 cm which was different from previous literatures (Table 1) where the petiole lengths were between 1.3 cm - 9.0 cm. This was probably because the plants used in this study were still at the nursery stage.

The var. *bilobata* showed significant differences in petiole length within plant parts, where upper plant part has the longest petiole length compared to the middle and lower parts (Table 5). The var. *trengganuensis* has the longest petiole length at the lower plant part as compared to the middle and upper plant parts.

The var. *bilobata* and var. *kunstleri* have longer means of petiole length at the upper plant parts. In contrast, var. *trengganuensis*, var. *intermedia*, var. *deltoidea* and var. *angustifolia* have longer means of petiole length at lower and middle parts of plant (Table 5).

The var. *kunstleri* and var. *trengganuensis* showed similarity in petiole length at the lower plant part, which was 2.3 cm. Other than that, var. *bilobata* and var. *intermedia* also showed approximately similar petiole length at the middle and lower plant parts. These results therefore, showed that the petiole length character is not useful in differentiating var. *kunstleri* and var.

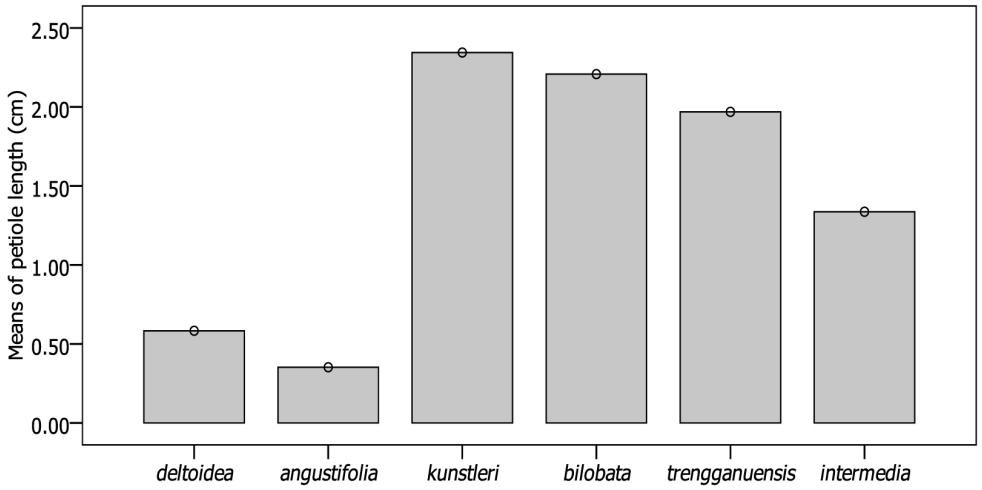

FIGURE 3. The total plant means of petiole length between varieties

TABLE 5. Comparison of petiole length for *Ficus deltoidea* variety by plant parts

Variety	Plant parts	Petiole length (cm) (Mean ± SE)	Test of significant (95% CI)
deltoidea	Upper	0.5 ± 0.1	*
	Middle	0.6 ± 0.1	*
	Lower	0.6 ± 0.1	*
angustifolia	Upper	0.3 ± 0.1	*
	Middle	0.4 ± 0.1	*
	Lower	0.4 ± 0.1	*
kunstleri	Upper	2.4 ± 0.1	*
	Middle	2.3 ± 0.1	*
	Lower	2.3 ± 0.1	*
bilobata	Upper	3.8 ± 0.1	*
	Middle	1.4 ± 0.1	*
	Lower	1.5 ± 0.1	*
trengganuensis	Upper	1.7± 0.1	*
	Middle	2.0 ± 0.1	*
	Lower	2.3 ± 0.1	*
intermedia	Upper	1.3 ± 0.1	*
	Middle	1.3 ± 0.1	*
	Lower	1.4 ± 0.1	*

Note:* Significant at 0.05, 0 outside 95%, CI. NS at 0.05, 0 with 95% CI

trengganuensis as well as between var. *bilobata* and var. *intermedia*.

LEAF AREA

Figure 4 shows the variations in total plant means of leaf area for six varieties of *Ficus deltoidea*. The greater total plant means of leaf area surface was from var. *kunstleri*. It was followed by var. *intermedia*, var. *trengganuensis*, var. *bilobata*, var. *deltoidea* and var. *angustifolia*.

Ficus deltoidea var. *trengganuensis* showed approximately similar mean of leaf area surface among the three parts of plant; upper, middle and lower (Table 6). The var. *trengganuensis* and var. *bilobata* have the widest

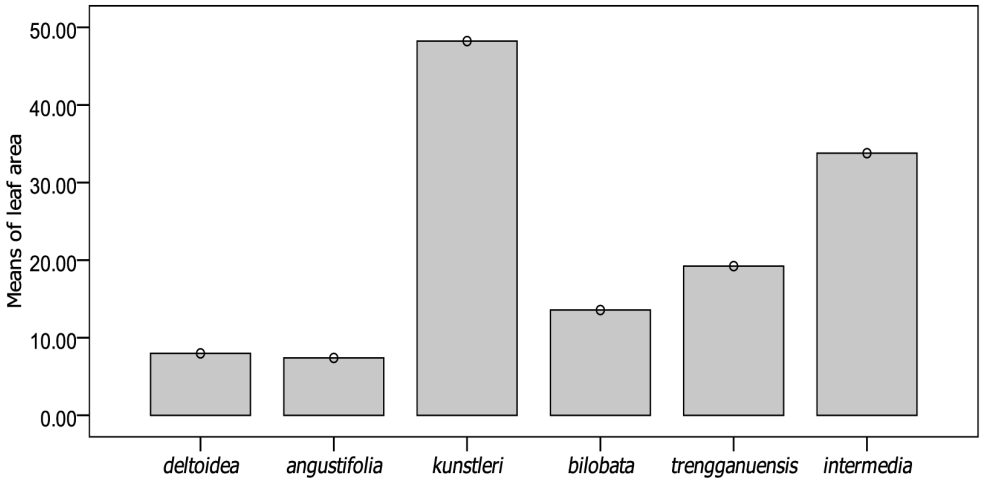

FIGURE 4. The total plant means of leaf area between varieties

TABLE 6. Comparison of leaf area for *Ficus deltoidea* Jack variety by plant parts

Variety	Plant parts	Leaf area (cm^2) (Mean ± SE)	Test of significant (95% CI)
deltoidea	Upper	7.6 ± 1.8	*
	Middle	8.3 ± 1.2	*
	Lower	8.1 ± 1.6	*
angustifolia	Upper	8.7 ± 1.8	*
	Middle	6.9 ± 1.2	*
	Lower	6.6 ± 1.6	*
kunstleri	Upper	53.9 ± 1.8	*
	Middle	44.0 ± 1.2	*
	Lower	46.9± 1.6	*
bilobata	Upper	12.6 ± 1.8	*
	Middle	13.2 ± 1.2	*
	Lower	14.9 ± 1.6	*
trengganuensis	Upper	18.9 ± 1.8	*
	Middle	19.2 ± 1.2	*
	Lower	19.6± 1.6	*
intermedia	Upper	38.2 ± 1.8	*
	Middle	30.3 ± 1.2	*
	Lower	32.9 ± 1.6	*

Note:* Significant at 0.05, 0 outside 95%. CI. NS at 0.05, 0 with 95% CI

mean of leaf area at the lower plant parts compared to the middle and upper parts of plant.

Ficus deltoidea var *deltoidea* has the narrowest leaf area surface at the upper part (7.6 cm^2) compared to the middle (8.3 cm^2) and lower plant parts (8.1 cm^2). On the other hands, var. *angustifolia* showed the widest leaf area surface at the upper part (8.7 cm^2) compared to the middle (6.9 cm^2) and lower parts (6.6 cm^2). Leaf area is not the recommended character to differentiate between var. *angustifolia* and var. *deltoidea* because it overlapped

in between the upper part and the middle part of plant in both varieties (Table 6).

Qualitative Measurement

Leaf Shape

Table 7 shows that there were leaf shape variations in six varieties of *Ficus deltoidea*. There was no variation in leaf shape from the upper, middle and lower plant parts of var. *deltoidea* and var. *kunstleri*. The shape of both var. *kuntsleri* and var. *deltoidea* was obovate (Table 7). As compared to previous studies (Table 2), Kochummen and Rusea (2000) stated that var. *deltoidea* leaf was deltoid. For var. *kunstleri*, Berg and Corner (2005) described that its leaf has obtriangular to obovate shapes.

Leaf shape of var. *angustifolia* showed differences between plant parts. The leaf shapes at upper part were spathulate (87%) and elliptic (13%), whilst they were oblanceolate (57%) and spathulate (43%) at the middle parts. Besides, at lower part of plant, they were oblanceolate (67%) and spathulate (33%). The var. *angustifolia* has the spathulate and oblanceolate to elliptic leaf shapes. However, these results were not similar with Corner (1969), who reported that var. *angustifolia* had spathulate or lanceolate leaf shape.

The var. *bilobata* variety showed no variation in its leaf shape at the lower part of plant but there were variations at the upper and middle plant parts. The upper part has obcordate (93%) and obovate (7%) shapes, but at the lower part there was only obcordate shape found (100%). As compared to previous researchers (Table 2), var. *bilobata* had spathulate, obdeltoid or obovate shapes. However, only obcordate shape has been discovered in var. *bilobata* in this study probably because this study was carried out on limited number of accessions.

Leaf shape of var. *trengganuensis* showed variations from the upper to lower parts of plants. There were more variations at the middle part compared to upper and lower parts of plant. Obovate shape occurred in large amount from the upper to lower parts in var. *trengganuensis* whilst the elliptic shape occurred only at the middle and lower parts of plant (Table 7). The occurrences of obcordate shape at the upper and middle parts were small at only 3% each.

Based on Table 7, var. *trengganuensis* has major occurrences of obovate and elliptic shapes. These results were relatively similar to Corner (1969), who reported that var. *trengganuensis* had various leaf shapes from elliptic to rounded obovate.

The var. *intermedia* showed significant leaf shape occurrences from upper to lower parts of plant where the leaf shapes were reportedly obovate to elliptic. At the upper and lower parts of plants, there were similar occurrences of leaf shape in var. *intermedia* which were elliptic (73%) and obovate (27%). There was no spathulate shape found in var. *intermedia*, as similarly reported by previous works (Table 2).

Heterophylly was observed in var. *angustifolia*, var. *bilobata*, var. *trengganuensis* and var. *intermedia* (Table 7). The elliptic and obovate shapes occurred for all three plant parts in the var. *intermedia*. Obovate shape occurred in five varieties of *Ficus deltoidea* except in var. *angustifolia*. There major leaf shape observed from upper, middle and lower plant parts in each variety; var. *deltoidea* was obovate (100%), var. *angustifolia* was sphatulate (87%), var. *kunstleri* was obovate (100%), var. *bilobata* was obcordate (100%), var. *trengganuensis* was obovate (97%) and var. *intermedia* was elliptic (77%).

TABLE 7. Comparison of leaf shape for *Ficus deltoidea* variety by plant parts

	Variety					
Parts	*deltoidea*	*angustifolia*	*kunstleri*	*bilobata*	*trengganuensis*	*intermedia*
Upper	Obovate (100%)	Spathulate (87%) Elliptic (13%)	Obovate (100%)	Obcordate (93%) Obovate (7%)	Obovate (97%) Obcordate (3%)	Elliptic (73%) Obovate (27%)
Middle	Obovate (100%)	Oblanceolate (57%) Spathulate (43%)	Obovate (100%)	Obcordate (93%) Obovate (7%)	Obovate (57%) Elliptic (40%) Obcordate (3%)	Elliptic (77%) Obovate (17%)
Lower	Obovate (100%)	Oblanceolate (67%) Spathulate (33%)	Obovate (100%)	Obcordate (100%)	Obovate (57%) Elliptic (43%)	Elliptic (73%) Obovate (27%)

LEAF BASE

According to Figure 5, almost all varieties of *Ficus deltoidea* have no variation in leaf base except for var. *angustifolia*. *Ficus deltoidea* showed only two leaf base shapes which were tapering (narrow or broad) and cuneate. These results were similar with previous works of Kochummen and Rusea (2000) who reported that the leaf base of *Ficus* is either cuneate or tapering. The var. *bilobata,* var. *trengganuensis,* var. *intermedia,* var. *kunstleri* and var. *deltoidea* have cuneate bases. Other than that, only var. *angustifolia* shows leaf base variations which are narrowly tapering and broadly tapering shapes (Figure 5).

LEAF APEX

Figure 6 shows the variation in leaf apex shape in six varieties of *Ficus deltoidea*. In this figure, var. *trengganuensis*,var. *intermedia* and var. *bilobata* showed more variation in leaf apex compared to other varieties. The var. *deltoidea* has two leaf apex shapes, which were rounded and truncate. The var. *angustifolia* and var. *kunstleri* have three shapes of leaf apex. The leaf apex of var. *angustifolia* was acuminate, rounded and obtuse whereas var. *kunstleri* has truncate, rounded and emarginated leaf shapes (Figure 6).

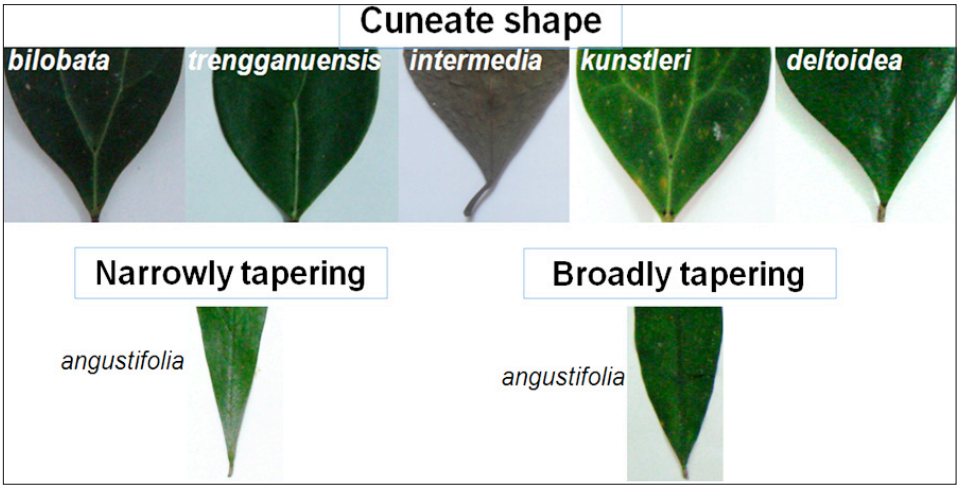

FIGURE 5. Leaf base shapes of *F. deltoidea* varieties

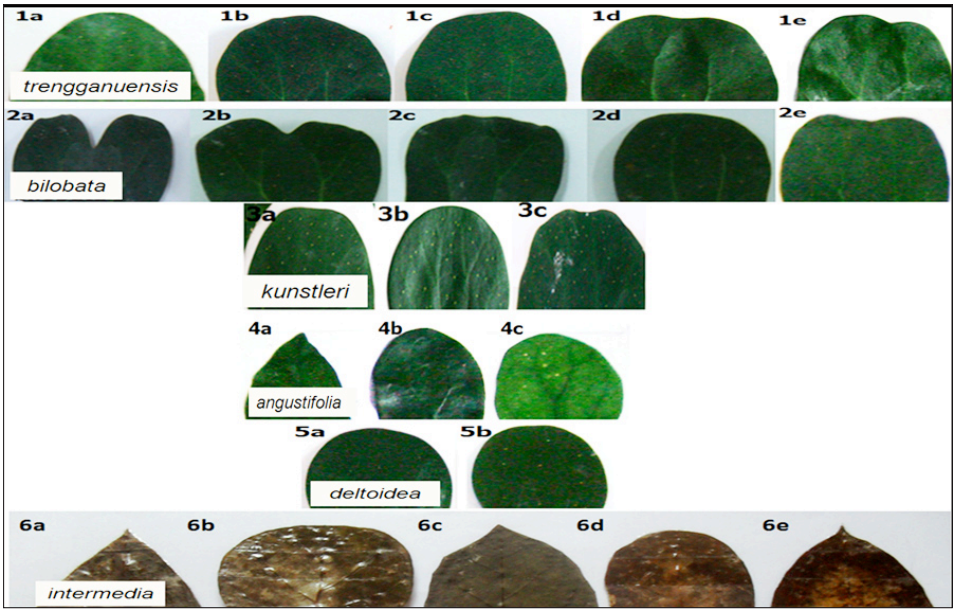

FIGURE 6. Shapes of leaf apex: 1a, 4b, obtuse. 1b, 2d, 3b, 4c, 5a, 6d, rounded. 1c, 2c, 3a, 5b, 6b, truncate. 1d, 2b, obcordate. 1e, 2a. cleft. 2e, 3c, emarginate. 4a, acuminate. 6a, acute. 6c, mucronate. 6e, cuspidate.

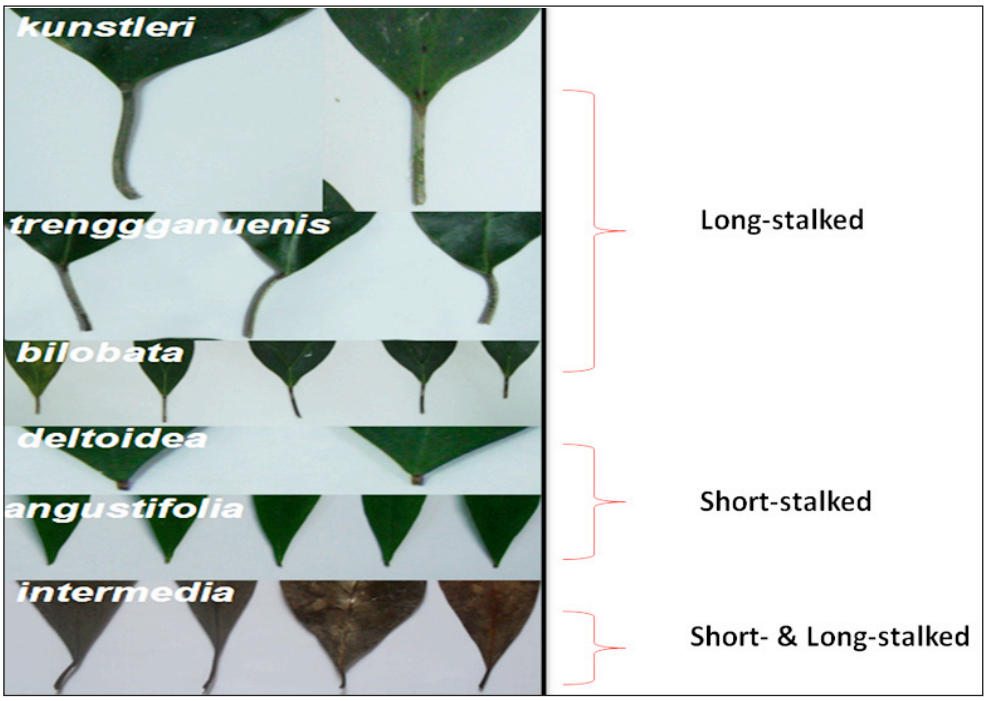

FIGURE 7. Leaf attachments in *Ficus deltoidea* varieties: 1, *kunstleri*. 2, *trengganuensis*. 3, *bilobata*. 4, *deltoidea*. 5, *angustifolia*

LEAF ATTACHMENT

According to Figure 7, six varieties of *Ficus deltoidea* were categorized into two petiole types which were long-stalked and short-stalked.

The var. *kunstleri*, var. *trengganuensis* and var. *bilobata* were categorized into long-stalked because their petiole lengths were more than 1.0 cm, whilst the var. *deltoidea* and var. *angustifolia* were observed to have the petiole lengths less than 1.0 cm and both of them were categorized as short-stalked. However, var. *intermedia* had both types of petiole which were long-stalked and short-stalked leaf attachments (Figure 7).

There were differences of results obtained from the quantitative or qualitative measurements from this study as compared to previous studies. This was because, in this study the measurement was carried out with the living plants whereas in the previous study it was carried out by using dried herbarium collections. Other than that, sampling was done by plant parts in this study whilst random samplings of herbarium specimens were carried out in previous studies for data collection purposes. Besides, results from this study complemented the published data as reported in the previous studies.

The leaf length cannot be recommended as the character to differentiate between the var. *deltoidea* and var. *bilobata* as well as between var. *angustifolia* and var. *bilobata* of *Ficus deltoidea*. On a similar note, the leaf width measurement was not recommended to differentiate between var. *trengganuensis* and var. *bilobata*. In addition, the petiole length measurement was also not applicable to differentiate between var. *kunstleri* and var. *trengganuensis* as well as between var. *bilobata* and var. *intermedia*. Besides, the leaf areas of var. *angustifolia* and var. *deltoidea* were also not recommended for comparing between both varieties. This problem arise because the varieties have similar or approximately similar selected quantitative measurements.

Heterophylly in leaf shape was detected in var. *intermedia*, var. *bilobata*, var. *trengganuensis* and var. *angustifolia* but not in var. *deltoidea* and var. *kunstleri*. Heterophylly in leaf apex was observed in all the six varieties studied where leaf apex at the lower plant part was different from the upper and middle plant parts. Leaf heterophylly was observed in *F. deltoidea* because foliage of the young plant was different from the matured plant.

CONCLUSION

Quantitative morphological measurements showed variations in leaf length, width and area and petiole length parameters in *F. deltoidea* varieties. The measurements were within the ranges that were previously reported except in the leaf length and width parameters of var. *angustifolia* and leaf width of var. *bilobata*, which were higher in this study. Qualitative observations showed consistency in the trends of leaf base variation between all plant parts of all varieties studied as well as in leaf attachment in all plant parts of var. *intermedia*, var. *kunstleri* and var. *trengganuensis*. Leaf heterophylly was reportedly occurred in *Ficus deltoidea* based on leaf shape and leaf apex, whereby the leaves from lower plant parts were different from upper and middle parts of plant.

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