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Abundance and flower utilisation of *Ficus deltoidea* (Moraceae) in different Malaysian oil palm plantations

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Abstract

Ficus deltoidea (Moraceae) is a common dioecious fig tree in Malaysian oil palm plantations. These plants are routinely cleared in commercial plantations. In this study, the distribution and flower utilisation of *F. deltoidea* from var. angustifolia, var. deltoidea, and var. trengganuensis from five oil palm plantations were determined from January to September 2017. The highest abundance of *F. deltoidea* per palm tree was recorded at Batu Pahat (1.67 ± 0.23) followed by Tembila (0.68 ± 0.11), and the least at Changkat Lobak plantation (0.38 ± 0.07). A significant difference in the numbers of flowers and flower utilisation across different varieties of *F. deltoidea* among five study sites. For the male figs, var. trengganuensis had the highest numbers of flowers and fig wasps produced while var. angustifolia recorded the lowest for both. The highest percentage of fig wasps produced was from var. deltoidea (63.67 ± 6.07%) while the lowest percentage was recorded from var. trengganuensis (36.23 ± 3.37%). Similar record was found in female, as var. trengganuensis had the highest numbers of flowers and seeds produced. However, the highest and lowest percentages of seed production were from var. angustifolia at Dengkil (90.05 ± 1.71%) and Changkat Lobak (79.25 ± 23.61%), respectively. In conclusion, the figs from different varieties of *F. deltoidea* showed a high degree of variation in terms of distribution, flower numbers, and reproductive outputs among three different varieties. *F. deltoidea* is considered as a valuable epiphyte because it produces fruits all year round may provide figs for frugivores.

Keywords: Characterisation, Distribution, Fig tree, True epiphytes

1. Introduction

Fig trees (*Ficus* spp., Moraceae) are native to Asia and can be found in the Mediterranean, Indian subcontinent, Latin America, Texas, Southern California to East Asia such as tropical rainforests in Malaysia [1]. The genus is characterised by having a special reproductive structure known as fig or syconium, which houses many small flowers inside and has an obligate mutualism with its pollinator, the fig wasp [2]. *Ficus* acts as a keystone species particularly in tropical forests in Southeast Asia due to its ability to produce abundant figs throughout the year, thus becoming the source of food for more than 1200 species of vertebrate frugivores [3]. In Peninsular Malaysia, at least 60 species of birds and 17 species of mammals have been recorded to eat figs [4]. There are more than 750 species of *Ficus* worldwide, making it one of the most numerous genera among terrestrial plants [5]. Malaysian forests house a high number of *Ficus* species with about 16% from all genera, equivalent to 101 species that have been identified [6]. *Ficus* species live in various forms including trees, true epiphytes, and shrubs, with more than half of them being hemiepiphytes [7].

Ficus deltoidea Jack. is locally known as *mas cotek* in the Malaysian community because of the presence of fine spots with a golden colour on the surface of the leaves [8]. *F. deltoidea* originates from and grows widely in Malaysia and other Southeast Asian countries [9]. Corner classified 13 varieties in *F. deltoidea*, with seven of them found in Peninsular Malaysia [10]. The varieties are var. *angustifolia* (Miq.), var. *deltoidea* Corner, var.

trengganuensis Corner, var. *kunstleri* King, var. *bilobata* Corner, var. *motleyana* (Miq.), and var. *intermedia* Corner. Three varieties of *F. deltoidea* commonly live as epiphytes in oil palm plantations in Peninsular Malaysia namely var. *angustifolia*, var. *deltoidea*, and var. *trengganuensis* [2]. *F. deltoidea* is often found on nutrient-poor soils, has a slow growth, and produces large seeds [7]. These traits may represent a pre-adaptation that has allowed them to survive as epiphytes, rather than as hemiepiphytes (stranglers).

F. deltoidea is dioecious, with separate male and female plants that either support fig wasp pollinators or produce seeds, respectively [2]. Whether the varieties of *F. deltoidea* are actually distinct species is unclear. Morphological studies of *F. deltoidea* show that all characters portray a high variability among the varieties [8]. This variation between and within species may be due to cross-pollination and sexual recombination between the species [11]. Genetic studies have shown that the gene flow occurs betwen varieties and the variation between the *F. deltoidea* varieties is reflected by morphological variation rather than the geographical origin of the plants [12].

Information regarding pollinators of *F. deltoidea* is scarce. The only pollinator recorded for *F. deltoidea* is *Blastophaga quadrupes* Mayr, which probably pollinates var. *lutescens* as it was collected in Java and Sumatra [10]. Morphological studies on fig wasps from three different varieties of *F. deltoidea* also showed high variability as the host trees [8,13]. The pollination of fig trees by fig wasps is one of the classic examples of obligate mutualism [8]. The mutualism between fig trees and fig wasps involves the pollination by the fig wasps and as a reward, the fig trees provide mating, development, and reproduction sites for the progeny together with the nutrition for the brood to complete their life cycle [14].

We addressed the following questions about *F. deltoidea* growing as epiphytes at oil palms in Peninsular Malaysia: [1] Which varieties of *F. deltoidea* are present at oil palm plantations? (2) Do they grow on the same individual palms as the fig trees? [3] Are there morphological differences in the floral numbers between three different varieties of epiphytic *F. deltoidea*? [4] Are there any differences in terms of the numbers of seeds and fig wasp progenies produced between all three varieties? [5] Are all parameters recorded differ between different oil palm plantations?

2. Materials and methods

2.1 Study site and study species

The study was carried out from June 2016 until August 2017 at five different oil palm plantations across Peninsular Malaysia. The study sites were chosen because they support *F. deltoidea* growing as epiphytes on oil palm trunks. The details on each study site are tabulated in Table 1. The abundance comparisons were made between three natural populations of *F. deltoidea* namely var. *angustifolia*, var. *deltoidea*, and var. *trengganuensis*.

Table 1 Details on all study sites.

Sites	Banting	Dengkil	Changkat lobak	Batu pahat	Tembila
State	Selangor	Selangor	Perak	Johor	Terengganu
Coordinates	2°50.094" N 101°35.074" E	2°51.125" N 101°39.424" E	5°07.070" N 100°39.445" E	5°07.070" N 100°39.445" E	5°43.402" N 102°39.445" E
Acre	4.57	40.53	2.00	4.94	320.00
Soil types	Peat	Silt	Peat	Peat	Sand
Oil palm age	17 years	23 years	29 years	27 years	11 years
Varieties present	var. *angustifolia*	var. *angustifolia*	var. *angustifolia*	var. *angustifolia*, var. *deltoidea*	var. *trengganuensis*

2.2 Observation and abundance of ficus deltoidea epiphytes on oil palm trunks in plantations

An initial identification of all the varieties was made by a botanist from Universiti Sultan Zainal Abidin (UniSZA), Prof Dr Nashriyah Mat. The differences in the morphology such as leaves and figs were noted (Figure 1). At each plantation, a total of 100 oil palm trees starting from the entrance were marked using global positioning system (GPS) devices (Garmin GPSMAP 76CSx). For each *F. deltoidea* individual, its variety was recorded as well as the sex if figs were present. The heights and diameters of the thickest stems of the fig trees were also noted. Some *F. deltoidea* were inaccessible and their details could not be recorded. The diameter of the thickest stem was measured using a Vernier calliper. For plant-apparent sex ratio assessment, the data were collected on 11 March 2017.

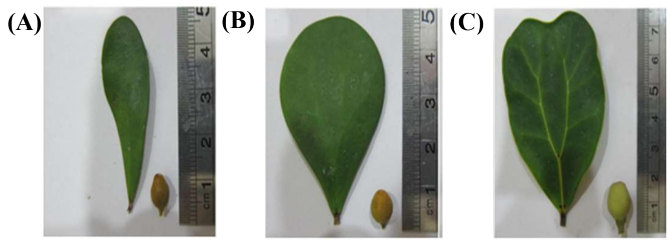

Figure 1 Morphological differences of leaf and fig of three different varieties of *Ficus deltoidea* (A) var. *angustifolia*, (B) var. *deltoidea*, (C) var. *trengganuensis*.

In all study plots, epiphytic *F. deltoidea* on oil palm trunks were observed and calculated. The number of *F. deltoidea* present on each oil palm tree, as well as its sex, was recorded. Sex determination was conducted by opening the fig. Each *F. deltoidea* tree was classified into four groups: male trees, female trees, figless trees, and inaccessible trees. A male tree is a fruit that has both male and female flowers, whereas a female tree has only female flowers and no male flowers (Figure 2). Figless indicates an *F. deltoidea* tree that does not produce fig, causing the sex of the tree unable to be determined. Next, inaccessible refers to an *F. deltoidea* tree that produces fig but is found above 3.5 m in height, making sex determination unfeasible.

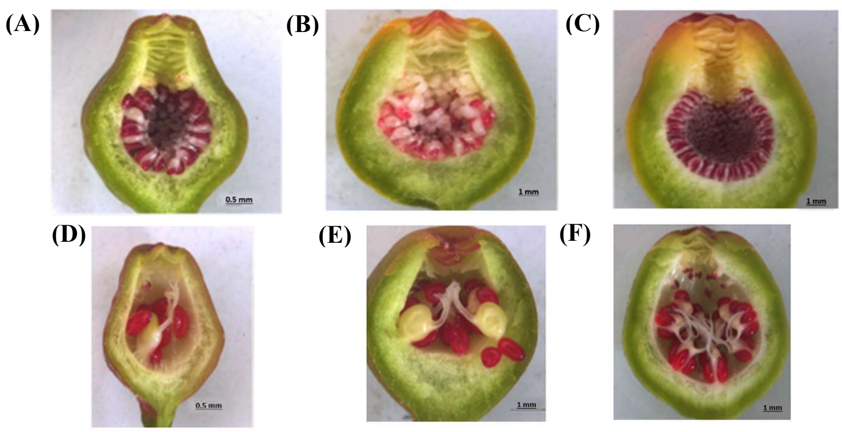

Figure 2 Male and female figs of *F .deltoidea* from three different varieties (A) male fig of var. *angustifolia*, (B) male fig of var. *deltoidea*, (C) male fig of var. *trengganuensis*, (D) female fig of var. *angustifolia*, (E) female fig of var. *deltoidea*, (F) female fig of var. *trengganuensis*.

2.3 Flower utilisation of F. deltoidea

The samples of var. *angustifolia*, var. *deltoidea*, and var. *trengganuensis* were obtained from natural wild fig trees growing as epiphytes in oil palm plantations in Peninsular Malaysia. A total of 200 figs from 10 male and 10 female trees from each study site were brought to the laboratories to be dissected (Table 2). The same sample size was obtained at a single site for populations of var. *deltoidea* (at Batu Pahat, Johor) and var. *trengganuensis* (at Tembila, Terengganu), providing a total of 200 figs for each variety.

Table 2 The number of figs from three different varieties of *F. deltoidea* from five study sites.

Variety	Site	n male trees (figs)	n female trees (figs)	Total figs
Angustifolia	Banting	10(10)	10(10)	200
	Dengkil	10(10)	10(10)	200
	Changkat Lobak	10(10)	10(10)	200
	Batu Pahat	10(10)	10(10)	200
Deltoidea	Batu Pahat	10(10)	10(10)	200
Trengganuensis	Tembila	10(10)	10(10)	200

All the samples were dissected under a stereomicroscope at 20× magnification for computational purposes. In the male fig, the fig was split into two or four parts. Then, the male flowers, female flowers, and galls were removed, separated, and counted using forceps. Similarly, for the female figs, the seeds and female flowers were removed and counted.

2.4 Statistical methods

Data for the abundance of *F. deltoidea* trees on each oil palm tree from different plantations were not normally distributed after normality tests were conducted. Thus, the data was transformed using square root transformation $\sqrt{X} + 0.5$ before being analysed using one-way analysis of variance (ANOVA) with different farm locations (Banting, Dengkil, Changkat Lobak, Batu Pahat, and Tembila) as independent factors. The same analysis was also conducted to find the mean differences of male trees, female trees, figless trees, and inaccessible trees for the five plantations. If the ANOVA test results demonstrated a significant difference ($p < 0.05$), the mean values of the factors were distinguished using the Tukey test at $p < 0.05$.

3. Results and discussion

3.1 Species abundance of three different varieties of Ficus deltoidea from five selected oil palm plantations

In total, there were 365 epiphytic *F. deltoidea* from three different varieties recorded from all the study areas. A total of 167 *F. deltoidea* trees were recorded at the Batu Pahat plantation followed by 68 trees at the Tembila plantation, 52 trees at the Dengkil plantation, and 40 trees at the Banting plantation, while the least number of *F. deltoidea* was recorded at Changkat Lobak plantation with only 38 trees. There was a significant difference in the abundance of *F. deltoidea* from five different oil palm plantations (ANOVA, F = 16.59; df = 4, 499; $p < 0.05$), where the Batu Pahat plantation had the highest mean of *F. deltoidea* trees at 1.67 ± 0.23 on a single palm tree (Figure 3). The same plantation also showed a significant difference in the overall mean number of epiphytic *F. deltoidea* trees compared to the other four oil palm plantations ($p < 0.05$). Tembila plantation recorded a mean value of 0.68 ± 0.11 per trunk of oil palm trees, and the abundance of *F. deltoidea* in this plantation did not show any significant difference with three other plantations (Banting, Dengkil, and Changkat Lobak) with $p > 0.05$.

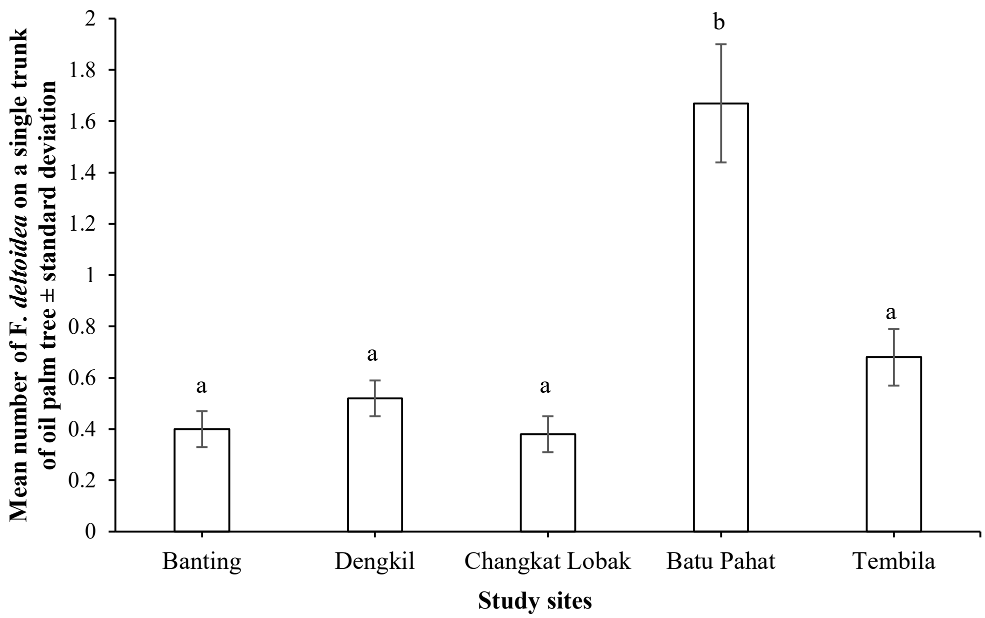

Figure 3 Mean ± standard deviation of the number of *Ficus deltoidea* on a single trunk of oil palm tree in five different oil palm plantations. Values with different superscripts differed significantly in Tukey tests ($p < 0.05$) based on localities.

The *F. deltoidea* trees found on each plantation were later divided into four groups namely male trees, female trees, figless trees, and inaccessible trees. For the Banting plantation, there was a significant difference in the mean number of epiphytes per host for all groups (ANOVA, F = 3.98; df = 3, 399; $p < 0.05$) (Figure 4). Figless trees recorded the highest mean on a single trunk (0.20 ± 0.05) while the lowest mean was recorded by inaccessible trees with 0.05 ± 0.02 per trunk. Tukey test showed that the figless tree category was different from the other groups. Dengkil plantation is the only plantation that showed a high similarity in the mean numbers of *F. deltoidea* on a single tree between all four groups (ANOVA, F = 1.73; df = 3, 399; $p > 0.05$). The highest mean was recorded on the female trees (0.19 ± 0.04) whilst the lowest mean was recorded from the figless trees (0.07 ± 0.03).

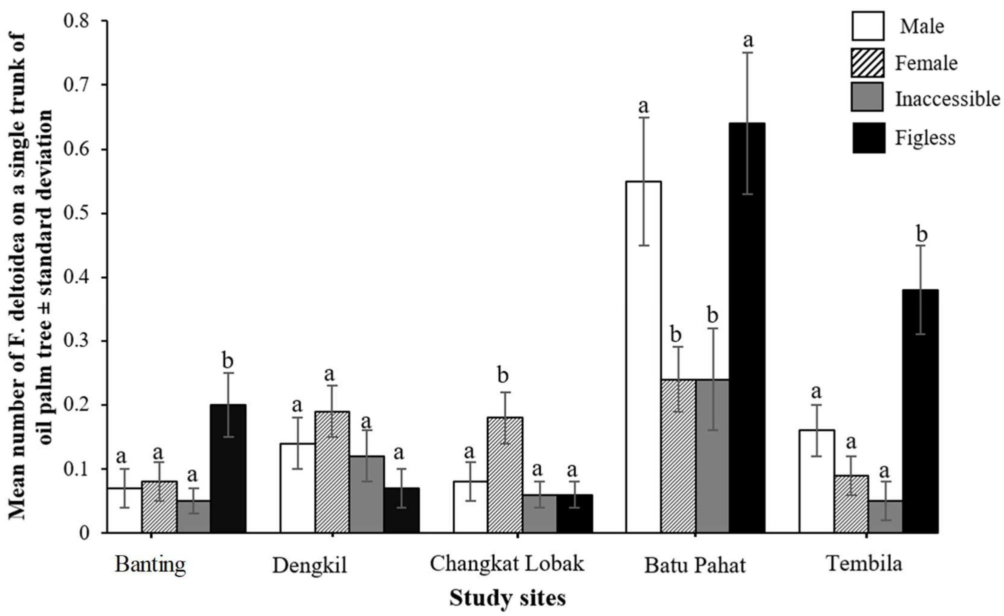

Figure 4 Mean ± standard deviation of the number of epiphytic *Ficus deltoidea* on a single trunk of oil palm tree in five different oil palm plantations.

A strong difference was found between the mean numbers of epiphytic *F. deltoidea* across the four groups at Changkat Lobak plantation (ANOVA, F = 3.65; df = 3, 399; $p < 0.05$) with the female trees being the group with the highest mean of 0.18 ± 0.04 on a single trunk. The lowest mean in this plantation was recorded in figless trees and inaccessible trees where they shared the same mean (0.06 ± 0.02). Tukey test showed that the female trees have a different significant mean ($p < 0.05$) compared with the other groups.

Batu Pahat plantation also showed a significant difference in mean value by group (ANOVA, F = 7.86; df = 3, 399; $p < 0.05$) with the highest mean recorded from figless trees with 0.64 ± 0.10. Two groups (female trees and inaccessible trees) recorded the same mean with 0.24 ± 0.05 and 0.24 ± 0.08 respectively (Figure 4), and these groups differ significantly with the other two groups (Tukey, $p < 0.05$). Another significant difference in mean between groups was recorded in Tembila plantation (ANOVA, F = 10.98; df = 3, 399; $p < 0.05$) where figless trees group recorded the highest mean per trunk (0.38 ± 0.07) thus making it differ significantly from the other groups (Tukey, $p < 0.05$). In this plantation, the lowest mean was recorded in the inaccessible trees group with the mean of 0.05 ± 0.03 on a single trunk.

Oil palms house a high number of epiphytes on their trunks. The epiphytes can partially mitigate the adverse effects caused by the conversion of natural habitat to oil palms, which generates a high degree of biodiversity loss [15]. This is because epiphytes can provide habitats and food for other organisms such as insects [16]. In Peninsular Malaysia, oil palms are often grown in areas that were once rubber plantations. The extent of epiphytes on the palm trees is strongly dependent on management intensity, but the architecture of the oil palm trunk provides very suitable host conditions for epiphytes [17].

Larger palm trees are expected to support more epiphytic *Ficus* as their larger size can accommodate more individuals [8] and fig trees are more likely to flourish on larger host trees. Larger palms are also likely to be older and to have had more time to be colonised. According to Boelter et al, soils and host size control the structure of epiphyte communities [18]. In this study, Banting, Changkat Lobak, and Batu Pahat plantations are on peat soil, Dengkil plantation is on silt soil, and Tembila plantation is on sandy soil. Peat soil has a high fibre content, low permeability, and low shear strength [19]. The sample size is too limited to conclude whether the soil type may have influenced which *Ficus* species grew on the palms, and the range of palm heights may have been too small to detect size effects. However, the trees were significantly smaller at Tembila, where the tallest palm was only 4.8 m high and the sandy soil there has less ability in retaining water and nutrients [20].

Apart from the management factor, there are various biotic and abiotic factors that determine the diversity and abundance of epiphytes such as weather, water, host tree size, and soil type [21]. Peat soil resulting from the accumulation of plant residues, stems, and roots has high organic matter, thus making the palm trees grow taller [22]. A taller trunk is capable of sustaining more epiphytes. In this study, the palm trees in Banting, Changkat Lobak, and Batu Pahat plantations were planted on peat soil while the palm trees in Tembila plantations were planted on sandy soil. Batu Pahat plantation had the highest height of the palm trunk and less intense management contributed to the highest mean number of *F. deltoidea* on a single trunk.

Peat soil stores carbon and energy and plays an important role in the water cycle and biogeochemistry [23]. On the other hand, the water and nutrient storage capacities of sandy soil are low [20]. According to Veloo et al., different soil types give a significant difference in oil palm yields [24]. The type of soil not only affects the growth and yield of oil palm, it also indirectly affects the growth of epiphytes that live on its trunk. The characteristics and fertility of the host tree play an important role in the success of the colonisation as well as the life of the epiphyte on its trunk [25].

The results at the time of study show that although the number of epiphytic *F. deltoidea* at the Tembila plantation was higher than those at the Banting and Changkat Lobak plantations, most of the *F. deltoidea* trees at this plantation did not produce fig. Similarly, at the Batu Pahat plantation, although the soil is peat, the number of trees that do not bear fig was the highest. More fig trees on a single trunk might be a possible explanation for the higher number of figless trees due to competition. Intraspecies competition might have occurred, which is usually more tense because the species individuals require the same resources [26].

Living on the same trunk triggers competition for light, humidity, and space and although there was no significant difference between the varieties in terms of abundance and height preferences, most of the *F. deltoidea* sharing a trunk did not produce figs and were often smaller in size than compared to other individuals that do not share the trunk [8]. The lack of nutrients may be inhibiting fig production. Many of the fig tree species recorded as epiphytes of the oil palms grow into large trees and only bear fruit once they have reached a large size [7].

Apart from the fig trees, oil palm trunks also house a collection of other epiphytic species. The extensive trunk of the oil palm and its long lifespan provide accommodation to a complex set of species. For example, oil palm trees are home to a high population of *langsuyar* fern epiphytes (*Asplenium nidus*) compared to the original forest [15]. The abundance of epiphytes also depends on the management and age of the trees at the plantation [26]. Each plantation has a different management system in terms of intensity and frequency (use of fertilisers and herbicides, standard of procedure, chemical selecting of plant removal, and removal of epiphytes on tree trunks) according to the judgement of the oil palm plantation manager [27].

Different plantations have different ages and types of soils that can affect the height of the trunks. Older palm trees can cater for more epiphytes; however, the management largely determines the abundance of the epiphytes and only some managers retain the epiphyte communities on the trunks without cutting them down. Many epiphytes including the fig trees appear to do no harm to palm oil production and management that encourages them should be encouraged [28]. Less intense management in smallholdings allows epiphyte communities to become well established on the oil palm trunks and maintain their complexity [22]. This contrasts with the actions typical of bigger companies. In big and managed plantations, epiphytes are routinely removed as they are seen as obstructing the collection of mature palm fruits [28].

According to a survey conducted on workers at the Banting farm, it was found that their activities indirectly removed the epiphytic trees that disturbed them during fruit harvesting. The farmers at Banting spray the ground vegetation in the plantation once every six months. The main purpose of the spraying is to eliminate weeds and other plants around the bases of the palms. The farmers do not deliberately want to spray the fig trees but some would be damaged, especially those growing low down on the trunks. In contrast, plantation owners in Batu Pahat do not remove the epiphytes found on oil palm stems or spray the ground vegetation in the plantation due to the lack of workers. The higher number of *F. deltoidea* (belonging to two varieties) at Batu Pahat may be because the plantation is very old and the palm trees barely produce fruit. Due to this fact, the owners may neglect cutting the epiphytes since they no longer need to collect the palm fruits. This plantation also acts as a source of *F. deltoidea* leaves for commercial products like tea and also for scientific research so cutting the fig trees would reduce their stocks.

Large and old trees usually have more epiphytic species than small trees because of higher rarity of settlement (availability of time and space) and microhabitat diversity [29]. In this study, the oil palm trees for each plantation are from 10 to 30 years old; however, relatively, the age of the oil palm trees does not cause a difference in the abundance of *F. deltoidea* trees. This is probably because most oil palm trees still have leaf foundation stems that provide places for *F. deltoidea* trees to grow. The composition of the plant community is the result of a combination of species-specific competition, seed availability, and dispersal [30]. *F. deltoidea* depends on fruit-eating animals such as birds, bats, rats, squirrels, and primates to spread its seeds [5,8,31-32].

3.2 Differences in the numbers of flowers, fig wasp offspring, and seeds from three different varieties of Ficus *deltoidea*

In this study, the differences of the contents in the male and female figs were recorded in three varieties of *F. deltoidea* namely var. *angustifolia*, var. *deltoidea*, and var. *trengganuensis*. Male fig trees from var. *trengganuensis* recorded the highest values for the mean numbers of male flowers, female flowers, and fig wasps in each male fig with 140.08 ± 2.61, 826.38 ± 9.67 and 301.34 ± 28.60 respectively (Table 3). In contrast, the male fig trees from var. *angustifolia* recorded the lowest mean values for all three parameters with 28.73 ± 0.78 for male flowers, 147.32 ± 10.16 for female flowers, and 65.79 ± 6.63 for fig wasp offspring. However, var.

angustifolia recorded the highest value for the mean proportion of successful reproduction in the fig wasp with 0.67 ± 0.72 while var. *trengganuensis* recorded the lowest mean proportion with 0.36 ± 0.10. Comparing the male figs of the three varieties, there was a significant difference in the mean numbers of male flowers (ANOVA, F = 1692.74; df = 2, 57; $p < 0.05$), female flowers (ANOVA, F = 1292.65; df = 2, 57; $p < 0.05$), fig wasp offspring (ANOVA, F = 59.87; df = 2, 57; $p < 0.05$), and the proportion of offspring (Kruskal Wallis, $\chi^2 = 10.49$; df = 2, 57; $p < 0.05$).

Table 3 Mean ± SD the number of male flowers, female flowers, and pollinator offspring in three different Piphytic *Ficus deltoidea*.

(Mean ± SD)	var. *angustifolia*	var. *deltoidea*	var. *trengganuensis*
Male flowers	28.98±0.20^a	57.91±10.84^b	140.08±1.62^c
Female flowers	141.38±2.50^a	150.35±2.05^a	826.38±10.14^b
Fig wasp	94.58±2.66^a	96.90±3.87^a	301.34±16.00^b
Proportion of offspring	0.67±0.72^a	0.64±0.18^a	0.36±0.10^b

For var. *angustifolia*, the numbers come from four different plantations. Values with different superscripts indicate that values differed significantly across varieties in Tukey tests and Pairwise comparison ($p < 0.05$).

Similar comparisons were conducted for the female figs of three varieties of *F. deltoidea* with less parameters counted. The highest mean values for the female flowers and seed numbers in the female figs were recorded from var. *trengganuensis* with 22.57 ± 0.42 and 18.47 ± 0.53, respectively (Table 4). There was a significance difference across the three varieties for the mean numbers of female flowers (ANOVA, F = 59.87; df = 2, 57; $p < 0.05$) and seeds produced in the female figs (ANOVA, F = 845.45; df = 2, 57; $p < 0.05$). In terms of the proportion of seed produced, var. *angustifolia* recorded the highest value with 0.86 ± 0.09 where no significant difference was detected for this parameter (Kruskal Wallis, $\chi^2 = 2.62$; df = 2, 57; $p > 0.05$).

Table 4 Mean ± SD the number of female flowers, seed and proportion of seed production in three different epiphytic *Ficus deltoidea*.

(Mean ± SD)	var. *angustifolia*	var. *deltoidea*	var. *trengganuensis*
Female flowers	4.91±0.52^a	7.96±1.30^b	22.57±1.25^c
Seed	4.22±0.74^a	6.77±1.95^b	18.47±1.58^c
Proportion of seed	0.86±0.09 ^{a}	0.84±0.07 ^{a}	0.81±0.06 ^{a}

For var. *angustifolia*, the numbers come from four different plantations. Values with different superscripts indicate that values differed significantly across varieties in Tukey tests ($p < 0.05$).

The varieties of *F. deltoidea* are distinguishable morphologically based on their size, shape, and colouration of the leaves [8,12,33]. The figs of some varieties also differ considerably in diameter [8]. These overlaps in characteristics have led to the variation being recognised in the form of many discrete varieties rather than species or most varieties not being recognised as distinct [7,10].

The most obvious differences between the three varieties (in both plant sexes) are fig sizes and the number of flowers they contain. The varieties with small figs also have small leaves and plants with big figs have big leaves [8]. The varieties with small figs are var. *angustifolia* and var. *deltoidea*, while var. *trengganuensis* produce big figs. This observation is concordant with the evolutionary trends in *F. deltoidea* described by Corner [10].

There was a considerable variation in the numbers of flowers within the male figs, but all the varieties had far more female flowers in male than female figs. This is in contrast to the usual pattern. Tarachai et al. for example recorded a mean of 858 female flowers in female figs of *Ficus hirta* Vahl. compared with a mean of 799 female flowers in male figs of this species [34]. The unusual occurrence in *F. deltoidea* results from the unusually small number of flowers in the female figs [10]. This extreme situation has been observed in the female figs of var. *bilobata*, where they only produced a single female flower in each fig. Consistently high ratio of anthers to ovules confirmed that the varieties are likely to be passively pollinated.

Furthermore, according to Herrera, the morphology of flowers is the same among different varieties, but there are quantitative differences between the same species [35]. As a result, var. *trengganuensis* figs have the most flowers compared to the other two varieties because this variety is the largest and thus able to place more flowers in each of its fruits compared to the other two varieties. In this study, all three varieties were from different locations except for those from the Batu Pahat oil palm plantation, where var. *angustifolia* and var. *deltoidea* shared the same farm and tree. Thus, the number of flowers as well as fig wasp offspring and seeds for each variety cannot be compared because each variety was obtained from different farms.

4. Conclusion

The diversity and abundance of *F. deltoidea* on the oil palm trunks were high. The plantations were not necessarily similar but showed that given suitable management, epiphytes can improve biodiversity in this form of monocultural agriculture. Morphological differences were present between the figs of different varieties, especially in the numbers of flowers that the figs contained. The production of the seeds and the fig wasp offspring between several varieties differ due to the morphological of the figs in association of the behaviour of their pollinators.

5. Acknowledgements

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