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# Floristic composition and species diversity of Sungai Udang Forest Reserve, Malacca, Peninsular Malaysia

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A study was conducted to determine the tree species composition and species diversity at Compartment 4 of Sungai Udang Forest Reserve, Malacca. A total of 1668 individual trees with diameter at breast height (DBH) of 5 cm and above were found in the 25 plots in Sungai Udang Forest Reserve, Malacca, Peninsular Malaysia of which overall floristic composition consisted of 85 species belonging to 79 genera and 38 families. The most abundant family is the Euphorbiaceae with 224 individual trees, followed by Myrtaceae and Anacardiaceae representing 212 and 197 individuals, respectively. Based on the calculated Importance Value Index (IVi), *Spondias cytherea* (Anacardiaceae) was the most important species in the study area with an importance value index (IVi) of 23.9%. The second most important species in the study area was *Syzygium* sp. (Myrtaceae) with an importance value index (IVi) of 22.8%, followed by *Elateriospermum tapos* (Euphorbiaceae) and *Aquilaria malaccensis* (Thymelaeaceae) with an importance value index (IVi) of 17.2% and 13.0%, respectively. As for species diversity, the Shannon-Weiner Diversity Index (H') for the whole 25 plots of the study area showed an index value of 3.67, while the Simpson's index of diversity (1-D) for the whole 25 plots showed an index value of 0.96. The H' values and D values proved that the study plots are considered as obtaining a fairly high species diversity in comparison with many studies conducted at the tropical rainforests in Peninsular Malaysia.

**Keywords: Floristic composition; importance value index; species diversity; Sungai Udang Forest Reserve**

## INTRODUCTION

According to Zhu (1997), tropical rain forest occurs mostly in valleys and on lower hills below 900 m altitude with a tropical moist climate due to a particular topography. The tropical rain forest appears as patches in local habitats and consisted of a mosaic pattern with montane evergreen forests and semi evergreen forests. The lowland tropical forest plants have extreme species diversity, very complex plant mosaic and involved time constraints, thus, the study on lowland tropical forest plants is considered complicated (Mohd Hasmadi et al. 2010). The forest in Malaysia has a high richness of tree flora which is due to high percentage of forest cover, thus, Malaysia is considered as fortunate (Saiful & Latiff, 2014).

The environmental conditions of tropical rainforests demonstrate high spatial variability and tropical rainforests are considered the most complex terrestrial ecosystems (Konishi et al.

2006). Forest values such as the biological diversity and ecological functions of forests cannot be protected by the plantation forest, thus, is frequently criticized (Son et al. 2007). Changes in environmental conditions largely influenced the growth of tropical secondary forest vegetation (Romell et al. 2008). According to Adekunle (2006), the most important characteristics of tropical rainforest ecosystem are species richness and distribution. The number of tree species is far larger in tropical rainforest than in any other forest community regardless of the size of the plot. The ecosystem that had been adversely affected and disturbed by the growing human population is indicated by any low number of trees and species encountered in the studied ecosystem.

Ashton (2008) stated that the service value of tropical lowland evergreen forests unequalled in any other terrestrial ecosystem is known as biological diversity or commonly abbreviated as biodiversity. The lowland evergreen tropical rain forests are known as the only place to sequester more than half of the total diversity of the planet. Additionally, the biodiversity of the Sunda Shelf, particularly Malaysia, Borneo and Sumatra, is second to the central and the Andean hinterlands of South America. Wan Razali (2012) added that tropical forests and tropical savannas have a high amount of carbon stored in both vegetation and soil as compared with temperate forests and temper ate grasslands. This indicated that the destruction of tropical ecosystems diminishes the natural carbon sinks due to the fact that they act as an efficient carbon sinks and eventually help to mitigate the adverse impacts of climate change. Several studies have indicated that depending on certain conditions, forest ecosystems can act as important sinks or sources of carbon (Nykvist & Sim, 2009). The tropical rain forest plants synthesize various chemicals as defense agents against pests, diseases and predators, thus, they contain assorted resources of biologically and chemically important components (Danial et al.2013). A logging cycle of 50 years is too short to keep the species composition of primary forests because 40-50 years is not enough time for a Malaysian tropical forest to recover its original species composition after logging (Yamada et al. 2013).

Previous studies have discovered that there are many important factors that could influence the floristic composition of a forest. Some of those mentioned factors are environmental gradients, anthropogenic pressure, topography and elevations, soil physical and chemical properties (Khairil et al. 2014; Kwan & Whitmore, 1970; Li et al. 2012; Millet et al. 2010; Saiful & Latiff, 2014). The complex characteristics of floristic composition is due to several parameters of disturbance such as time, intensity and repetition could affect regeneration of the original floristic composition and soil condition (Millet et al. 2010). A study by Munishi et al. (2007) stated that areas with excellent conditions to survive and reproduce are favorable to the plants. Moisture, soil physical and chemical properties and other physical characteristics of the landscape are factors that influence the growth of plants in a particular environment. Distinct plant communities are the formation of an association between plants that respond to the same environmental factors equally. Sato (2009) concluded that environmental changes might significantly impact the biodiversity of subdominant species, even though such changes do not show clear effects on dominant canopy species or whole forest structure. Nizam et al. (2012) also suggested that the floristic patterns are influenced by the environmental gradients. The essential formula to protect and conserve forest habitats is by identifying environmental gradients such as abiotic conditions and major soil that influences the vegetation patterns.

One of the reasons tropical rainforest was chosen in this study is because of its well-known complex terrestrial ecosystem. Malaysia has a tropical rainforest that is very rich with tree flora and biodiversity. However, the disturbing destruction due to human impact faced by the tropical rainforest could cause the depletion of the tropical rainforest in future. This has led to an abundant of research on the tropical rainforest and it is highly expected that this study could contribute more in understanding the tropical rainforest, thus, could be an advantage to the tropical forest conservation and management.

The aims of this study are to identify, characterize and classify the floristic composition of the naturally distributed forest communities and to provide information on species diversity of the plant communities.

## MATERIALS AND METHODS

### Study Site

Floristic composition of the tropical trees was obtained from a 135 acre of forest reserve at Sungai Udang, Malacca, Malaysia (2°19′N, 102°8'E) (Fig. 1). The Sungai Udang Forest Reserve is a lowland dipterocarp forest and is home to various flora and fauna. The area has a rough topography and ranges in altitude from 10 m to 90 m.

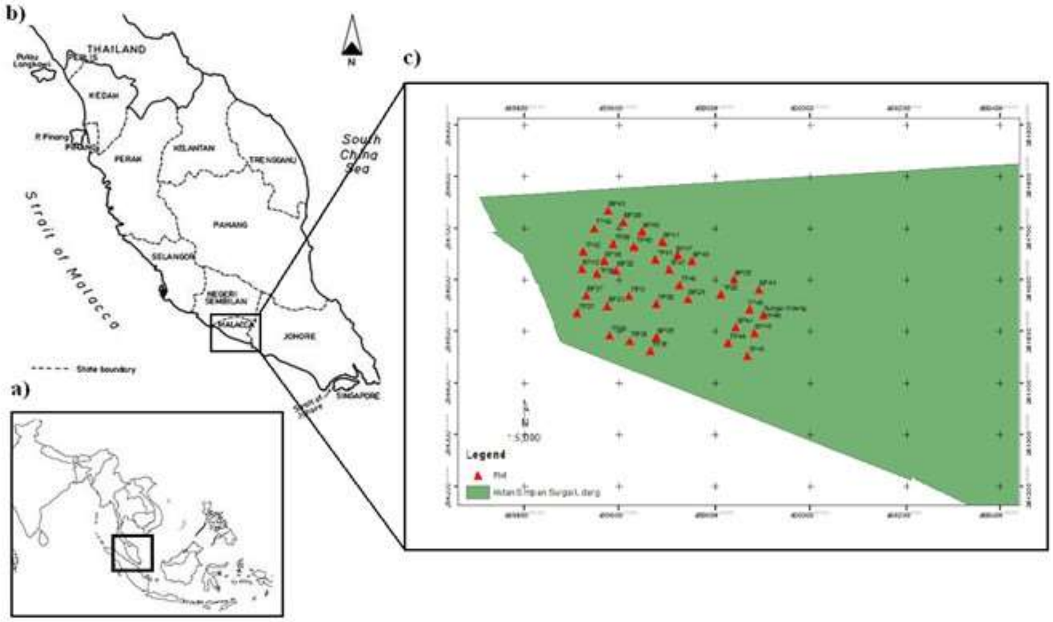


**Figure 1: (a) Map of Southeast Asia outlining the Peninsular Malaysia, (b) map of Peninsular Malaysia showing the location of the study site, and (c) map of the study site within the Sungai Udang Forest Reserve (Malacca, Malaysia). Triangulars indicate the locations of sampling plots in the study site.**

The data were collected within the boundary of 20 hectares of forest reserve known as Compartment 4. Sungai Udang Forest Reserve was declared in 1987 to be a permanent forest reserve area comprising the remaining approximately 335 acres of land area. It is bordered by Jalan Masjid Tanah stream to the west, a military camp on the north, an estate on the east and a Rela Camp to the south of the forest reserve. About 80 acres of the forest reserve bordering the army camp has been logged and replanted. Sungai Udang Forest Reserve was divided d into four compartments. Compartment 1 is for the recreational area. Compartment 2 is used for camping area. Compartment 3 is an area which is provided for the visitors to explore. Compartments 4 is an untouched preserved forest and are protected from the logging activities. The area has a tropical rainforest climate of which is punctuated by much rainfall. The rainy seasons or heavy monsoon season occurs in October through March every year. The dry season occurs from May through July every year. The weather is warm and humid all year round with temperatures ranging from 21º C to 32º C. Mean annual rainfall of the study area is recorded as 2000 mm and it is considered to be one of the driest areas in Malaysia. Mean annual maximum and minimum precipitation is recorded as 74% and 35% respectively. The relative humidity typically ranges from 54% to 96% throughout the year.

**Vegetation sampling**

Field surveys and data collection was carried out from September 2012 to April 2013. A total of 25 plots (20 m × 40 m) in size were constructed according to the line transect method. The size of the plots was estimated by means of a "minimal area" which was 800 m2 in each plot. Plots were 20 m from each other. The plots were located at various altitudes, expositions, inclinations, and relief. An effort was made to achieve a higher ecological and physiognomic homogeneity within each plot. Every plot was georeferenced with a Garmin GPS Map 60 CS.

The scientific names of each vascular species in each plot were identified. All vascular plant species in each plot with a trunk diameter at breast height (DBH) ≥ 5 cm were marked and numbered, and their diameters and heights were measured and recorded. Trunk perimeter measurements were taken using a metric tape and tree heights were estimated with the aid of a clinometer.

Specimens of all recorded trees were collected for the preparation of voucher specimens and for species identification. The identification of the specimens was made possible using keys in taxonomic references such as the Tree Flora of Malaya (Whitmore, 1972).

### Statistical Analysis

Species diversity was determined by using the Shannon-Wiener Diversity Index (H') (Shannon & Weaver, 1963) and the Simpson (1949) index of Dominance. Importance Value Index is used to determine the overall importance of each species in the community structure of the research area. In calculating this index, the percentage values of the relative density, relative frequency, and relative dominance are summed up together and this value is designated as the Importance Value Index or IVi of the species (Curtis, 1959) as follows: IVi = RDi + RFi + RBi ; where RDi is the relative density of species I , RFi is the relative frequency of species I , RBi is the relative dominance (basal area) of species I.

## RESULTS

### Floristic Composition

A total of 1668 individual trees with diameter at breast height (DBH) of 5 cm and above were found in the 25 plots in Sungai Udang Forest Reserve, of which overall floristic composition consisted of 85 species belonging to 79 genera and 38 families (Table 1).

**Table 1: Number of genera and species for all families present in all 25 plots**

| No. | Family | No. of genera | No. of species | No. of individuals |
|---|---|---|---|---|
| 1 | Anacardiaceae | 4 | 6 | 197 |
| 2 | Annonaceae | 3 | 3 | 27 |
| 3 | Arecaceae | 1 | 1 | 9 |
| 4 | Bombacaceae | 2 | 2 | 20 |
| 5 | Burseraceae | 1 | 1 | 2 |
| 6 | Clusiaceae | 3 | 3 | 45 |
| 7 | Combretaceae | 1 | 1 | 1 |
| 8 | Dilleniaceae | 1 | 1 | 4 |
| 9 | Dipterocarpaceae | 2 | 2 | 29 |
| 10 | Ebenaceae | 1 | 2 | 37 |
| 11 | Elaeocarpaceae | 1 | 1 | 18 |
| 12 | Euphorbiaceae | 9 | 9 | 224 |
| 13 | Fabaceae | 8 | 8 | 58 |
| 14 | Fagaceae | 1 | 1 | 41 |
| 15 | Flacourtiaceae | 2 | 2 | 6 |
| 16 | Hypericaceae | 1 | 1 | 7 |
| 17 | Ixonanthaceae | 1 | 2 | 37 |
| 18 | Lauraceae | 1 | 1 | 78 |
| 19 | Lecythidaceae | 1 | 1 | 26 |
| 20 | Melastomataceae | 2 | 2 | 27 |
| 21 | Meliaceae | 5 | 5 | 34 |
| 22 | Moraceae | 4 | 6 | 75 |
| 23 | Myristicaceae | 1 | 1 | 53 |
| 24 | Myrsinaceae | 1 | 1 | 5 |
| 25 | Myrtaceae | 2 | 2 | 212 |
| 26 | Olacaceae | 1 | 1 | 39 |
| 27 | Oxalidaceae | 1 | 1 | 22 |
| 28 | Pandanaceae | 1 | 1 | 2 |
| 29 | Rhizophoraceae | 2 | 2 | 17 |
| 30 | Rubiaceae | 5 | 5 | 109 |
| 31 | Rutaceae | 1 | 1 | 12 |
| 32 | Sapindaceae | 1 | 1 | 6 |
| 33 | Sapotaceae | 1 | 1 | 33 |
| 34 | Simaroubaceae | 1 | 1 | 9 |
| 35 | Sterculiaceae | 2 | 2 | 5 |
| 36 | Theaceae | 2 | 2 | 17 |
| 37 | Thymelaeaceae | 1 | 1 | 56 |
| 38 | Ulmaceae | 1 | 1 | 69 |
| | Total | 79 | 85 | 1668 |

The most abundant family was Euphorbiaceae with 224 individual trees, and represented by 9 species in 9 genera namely; *Antidesma* sp., *Baccaurea parviflora, Blumeodendron subcaudatum, Drypetes* sp., *Elateriospermum tapos, Endospermum diadenum, Macaranga gigantia* and *Sapium baccatum.* Myrtaceae was the second most abundant family, with 2 genera and 2 species (212 individual trees) namely; *Rhodamnia cinerea* and *Syzygium* sp. It was followed by Anacardiaceae with 4 genera and 6 species (197 individual trees) namely; *Bouea macrophylla, Bouea oppositifolia, Buchanania subobovata, Spondias cytherea, Swintonia penangiana* and *Swintonia*

In addition, there was one family that was represented with only one species and one individual in the study plots, namely, Combretaceae. With the least number of species and individual, this family is considered as the most uncommon family within the study plots.

The most abundant species was *Syzygium* sp. (Myrtaceae) with 210 individuals followed by *Spondias cytherea* (Anacardiaceae) with 144 individuals and *Elateriospermum tapos* (E uphorbiaceae) with 129 individuals, respectively.

The DBH distribution of trees in this study is summarized in Table 2. Majority of the trees in this study area (875 individuals) fall into Class One which was the group of trees with a diameter of breast height between 5 cm to 14.90 cm. Class Seven which was the group of trees with a diameter of breast height of more than 65.00 cm had the lowest number of individuals in this study which was 27 individuals.

Table 3 shows the largest ten individual trees in the plots of the study area. The study area showed an existence of several large trees ranged from 55 m to 45 m of which were tall enough to form the emergent canopy. Both *Artocarpus rigidus* (Moraceae) and *Ixonanthesret iculata* (Ixonanthaceae) was the largest tree in the study area and stated a similar diameter at breast height which was 110 cm and 55 cm in height, followed by *Paratocarpus bracteatus* with 94 cm in diameter at breast height and 53 cm in height.

### Species Importance

### Relative Density

The value of relative density for this study ranged from 0.1% to 12.6% (showed that the density of each species has a wide gap). *Syzygium* sp. (Myrtacea) with 210 trees was the species with the highest density in this study and represented 12.6% of total trees in this study. The species with the second highest density was *Spondias cytherea* (Anacardiaceae) with 144 trees and represented 8.6% of total trees in this study, followed by *Elateriospermum tapos* (Euphorbiaceae) and *Litsea firma* (Lauraceae) with 129 trees (7.7%) and 78 trees (4.7%), respectively. The ten leading species with the highest relative density of this study were listed in Table 4 in descending order.

### Relative Frequency

*Elateriospermum tapos* (Euphorbiaceae) appeared most frequently in this study with a frequency of 96%. Both *Spondias cytherea* (Anacardiaceae) and *Syzygium* sp. (Myrtacea) had the second highest frequency which was 92%, followed by both *Litsea firma* (Lauraceae) and *Porterandia anisophylla* (Rubiaceae) with a frequency of 88%. The ten leading species with the highest frequency of this study were listed in Table 5 in a descending order.

### Basal Area

The ten species with the highest basal area are listed in Table 6 in descending order. Total basal area of this study was 63.12 $m^2$ $ha^{-1}$. *Spondias cytherea* (Anacardiaceae) had the highest total basal area in the study area with a value of 7.87 $m^2$ $ha^{-1}$. The species with the second highest total basal area was *Artocarpus rigidus* (Moraceae) with a value of 5.11 $m^2$ $ha^{-1}$ followed by *Aquilaria malaccensis* (Thymelaeaceae) and *Syzygium* sp. (Myrtaceae) with a value of 4.81 $m^2$ $ha^{-1}$ and 4.47 $m^2$ $ha^{-1}$, respectively.

### Importance Value Index

The Importance Value Index ($IV_i$) of ten leading species at the study area in Sungai Udang Forest Reserve, Malacca is shown in Table 7. Based on the calculated Importance Value Index ($IV_i$), *Spondias cytherea* (Anacardiaceae) was the most important species in the study a rea with an importance value index ($IV_i$) of 23.9%. The second most important species in the study area was *Syzygium* sp. (Myrtaceae) with an importance value index ($IV_i$) of 22.8%, followed by *Elateriospermum tapos* (Euphorbiaceae) and *Aquilaria malaccensis* (Thymelaeaceae) with an importance value index ($IV_i$) of 17.2% and 13.0%, respectively.

### Species Diversity

Table 8 shows the values of the diversity indices for the study area. The Shannon-Weiner Diversity Index (*H'*) for the forest of the study area

**Table 2: DBH distribution of this study area in Sungai Udang Forest Reserve**

| Diameter class | Number of trees |
|---|---|
| CLASS 1: 05.00 - 14.90 cm | 875 |
| CLASS 2: 15.00 – 24.90 cm | 400 |
| CLASS 3: 25.00 – 34.90 cm | 190 |
| CLASS 4: 35.00 – 44.90 cm | 90 |
| CLASS 5: 45.00 – 54.90 cm | 37 |
| CLASS 6: 55.00 – 64.90 cm | 49 |
| CLASS 7: Above 65.00 cm | 27 |

**Table 3: The 10 largest trees found in this study**

| Species | Vernacular name | Family | DBH (cm) | Height (m) |
|---|---|---|---|---|
| *Artocarpus rigidus* | Keledang | Moraceae | 110 | 55 |
| *Ixonanthes reticulata* | Inggir burung | Ixonanthaceae | 110 | 55 |
| *Paratocarpus bracteatus* | Ara bertih bukit | Moraceae | 94 | 53 |
| *Artocarpus rigidus* | Keledang | Moraceae | 92 | 51 |
| *Endospermum diadenum* | Sesenduk | Euphorbiaceae | 87 | 50 |
| *Callerya atropurpurea* | Tulang daing | Fabaceae | 85 | 50 |
| *Parkia javanica* | Petai kerayung | Fabaceae | 85 | 50 |
| *Shorea leprosula* | Meranti tembaga | Dipterocarpaceae | 84 | 50 |
| *Dacryodes rugosa* | Kedondong matahari | Burseraceae | 82 | 45 |
| *Aglaia* sp. | Medang | Meliaceae | 82 | 45 |

**Table 4: The ten leading species with the highest relative density in the study area at Sungai Udang Forest Reserve, Malacca**

| Species | Relative Density (%) |
|---|---|
| *Syzygium* sp. | 12.6 |
| *Spondias cytherea* | 8.6 |
| *Elateriospermum tapos* | 7.7 |
| *Litsea firma* | 4.7 |
| *Porterandia anisophylla* | 4.3 |
| *Gironniera nervosa* | 4.1 |
| *Aquilaria malaccensis* | 3.4 |
| *Knema* sp. | 3.2 |
| *Baccaurea parviflora* | 2.8 |
| *Lithocarpus* sp. | 2.5 |

**Table 5: The ten leading species with the highest frequency in the study area at Sungai Udang Forest Reserve, Malacca**

| Species | Frequency (%) |
|---|---|
| *Elateriospermum tapos* | 96 |
| *Spondias cytherea* | 92 |
| *Syzygium* sp. | 92 |
| *Litsea firma* | 88 |
| *Porterandia anisophylla* | 88 |
| *Swintonia schwenkii* | 76 |
| *Knema* sp. | 76 |
| *Ixonanthes icosandra* | 68 |
| *Ochanostachys amentaceae* | 68 |
| *Gironniera nervosa* | 68 |

**Table 6: Ten species with the highest basal area of the study area**

| Species | Basal Area ($m^2$ $ha^{-1}$) |
|---|---|
| *Spondias cytherea* | 7.87 |
| *Artocarpus rigidus* | 5.11 |
| *Aquilaria malaccensis* | 4.81 |
| *Syzygium* sp. | 4.47 |
| *Aglaia* sp. | 4.39 |
| *Elateriospermum tapos* | 3.87 |
| *Endospermum diadenum* | 2.75 |
| *Shorea leprosula* | 2.43 |
| *Lithocarpus* sp. | 1.89 |
| *Porterandia anisophylla* | 1.71 |

**Table 7: The ten leading important species at Sungai Udang Forest Reserve study area in descending order of its Importance Value Index ($IV_i$)**

| Species | $IV_i$ (%) |
|---|---|
| *Spondias cytherea* | 23.9 |
| *Syzygium* sp. | 22.8 |
| *Elateriospermum tapos* | 17.2 |
| *Aquilaria malaccensis* | 13.0 |
| *Artocarpus rigidus* | 11.7 |
| *Porterandia anisophylla* | 10.2 |
| *Litsea firma* | 9.4 |
| *Gironniera nervosa* | 7.9 |
| *Swintonia schwenkii* | 7.7 |
| *Aglaia* sp. | 7.2 |

**Table 8: Species diversity indices for the forest of study area**

| Indices | Value |
|---|---|
| Shannon diversity index (H') | 3.67 |
| Simpson diversity index (1-D) | 0.96 |

showed an index value of 3.67. Meanwhile, The Simpson's index of diversity (1-D) for the forest of the study area showed an index value of 0.96.

## DISCUSSION

### Floristic Composition

The floristic composition in the family level obtained in this study with Euphorbiaceae as the dominant family is quite similar from those found in other tropical forest in Peninsular Malaysia. Different forest structures can have similar floristic composition (Millet et al. 2010). Several studies have also reported similar observation of which Euphorbiaceae was the most speciose family in their study areas (Khairil et al. 2014; Lajuni & Latiff, 2013; Mardan et al. 2013; Nizam et al. 2012; Saiful & Latiff, 2014).

For instance, a study on the species composition and floristic variation of tree communities at Kenong Forest Park, Kuala Lipis, Pahang, Malaysia has reported Euphorbiaceae as the most speciose family of which was represented by 40 species in 15 genera (Nizam et al. 2012). Meanwhile, a study of biomass and floristic composition at Bangi Permanent Forest Reserve recorded Euphorbiaceae as the largest family with 10 genera and 119 species (Lajuni & Latiff, 2013). A study of tree species composition and diversity in Ulu Muda Forest Reserve, Kedah, Malaysia has also reported Euphorbiaceae as the largest family with 11 genera and 20 species (Mardan et al. 2013).

Saiful and Latiff (2014) have done a study on the effects of selective logging on tree species composition, richness and diversity and stated that Euphorbiaceae was not only dominant before logging with 24 species and 116 individual trees, but also maintain the dominancy after the devastating logging activity in a primary hill dipterocarp rainforest in Peninsular Malaysia, with 20 species and 73 individual trees.

A study by Khairil et al. (2014) reported a similar result with this study of which Euphorbiaceae had the highest density in inland and riverine forests with 266 and 197 individuals $ha^{-1}$ respectively, while Myrtaceae had the highest density in seasonal flood forest with 168 individuals $ha^{-1}$. Disturbed areas can amplify the density of Myrtaceae and the severity of the disturbance can have an impact accordingly on the abundance of Myrtaceae (Prado Júnior et al. 2014). Among the common shrubs found in the coastal region of Peninsular Malaysia are known as Myrtaceae or myrtles (Mat-Salleh et al. 2003). The dominance of Euphorbiaceae is expected and not startling as Euphorbiaceae is well-known to dominate or co-dominate many lowland forests of Malaysia and other short stature vegetation formations, bushes and secondary vegetation (Whitmore, 1972).

A study by Abdul Hayat et al. (2010) on the plant species diversity of a logged-over coastal forest within the Pasir Tengkorak Forest Reserve, Langkawi, Malaysia reported quite a similar result with this study of which Anacardiaceae and Myrtaceae families were the most common species and widespread all over the country. However, Abdul Hayat et al. (2010) stated that Myrtaceae family was commonly found in the coastal beach, while Anacardiaceae was commonly found at the lowland forest.

The majority of the trees studied fall into DBH class one with 875 individuals showed that the forest of the study area consisted of mostly young trees and saplings, thus, is an actively regenerating forest. The DBH distribution obtained in this study is similar to those obtained by Lajuni and Latiff (2013) in their study on the floristic composition of Bangi Permanent Forest Reserve, which most of the trees also fall into DBH class one with 669 numbers of trees.

The existence of several large trees in the study area ranged from 55 m to 45 m, which are tall enough to form the emergent canopy indicated that Sungai Udang Forest Reserve is a matured or climax forest. One of these trees which is *Shorea leprosula* (Dipterocarpaceae) is a commercial timber tree. Anacardiaceae, Dipterocarpaeae, Guttiferae, Myristicaceae, Myrtaceae, Melastomataceae, Palmae, and Sapotaceae generally demonstrated a higher species richness and importance in rain forests of Southeast Asia (Zhu, 1997).

### Species Importance

A species with important value index of more than 10% is considered as the dominant species in a particular community (Curtis and Macintosh, 1951). A study by Nizam et al. (2012) included *Elateriospermum tapos* as the most important species with importance value index of 1.98% at one of their study site. A study by Khairil et al. (2014) also reported quite a similar result with this study where both Myrtacea and Euphorbiaceae were found to be one of the most important families in their study area.

According to Lajuni and Latiff (2013), the importance value index is used as a significant parameter in giving information on the timber value of a forest. A particular forest will be classified as an economically valuable forest if the species with the highest importance value index of that particular forest belongs to a valuable timber species. However, the importance value index of the timber species in this study was not high enough to be classified as such. For example, in this study *Shorea leprosula* and *Hopea* sp. which are well-known as one of the most economically valuable timber species only showed an importance value index of 5.6% and 1.8%, respectively. This was due to the fact of the disturbance by logging in some part of the study area, of which has diminished most of the valuable timber species.

### Species Diversity

Species richness (the number of different species in a particular area) that is weighted by some measure of abundance such as number of individuals or biomass is identified as species diversity (Abdul Hayat et al. 2010). The Shannon-Weiner Diversity Index (*H'*) values of this study are considered as obtaining a fairly high species diversity in comparison with many studies conducted at the tropical rainforests in Peninsular Malaysia. A low value of Shannon H' indicates domination by a few species, while a high value of Shannon H' indicates a large number of species with similar abundances (Saiful & Latiff, 2014).

For instance, a study at Kenong Forest Park, Kuala Lipis, Pahang, Malaysia on species composition and floristic variation of tree communities in two distinct habitats recorded a fairly high species diversity with *H'* value of 4.42 (limestone cave) and *H'* value of 4.79 (lowland area) (Nizam et al.2012). Meanwhile, a study of biomass and floristic composition at Bangi Permanent Forest Reserve recorded a value of 6.99 which indicated the existence of a large number of species with similar abundances (Lajuni & Latiff, 2013).

These fairly high species diversity values also indicated that the study plots are considered able to conserve tree species diversity. For instance, a study on the tree species diversity at three sites in tropical rainforest ecosystem of South-West Nigeria reported quite a similar result with the H' value of 3.66 (Shasha Forest Reserve), H' value of 3.62 (Ala Forest Reserve) and H' value of 3.34 (Omo Forest Reserve), and suggested that the sites were able to conserve tree species diversity (Adekunle, 2006).

A study on the plant species diversity of the Pasir Tengkorak Forest Reserve, Langkawi, Malaysia also reported quite a similar result with this study of which the Simpson's index of diversity was 0.96, which suggested that diversity is high in the 1ha plot of the study area (Abdul Hayat et al., 2010).

## CONCLUSION

This study shows that the plants in this study can successfully interact socially with each other and can live healthily together in an ecosystem. This was proven from the fairly high species diversity obtained from the study area. High species diversity of the study area means it has a great number of successful species and a stable ecosystem. High species diversity also suggests that the study area has a complex food webs and an environmental change is harmless and unlikely will damage the ecosystem as a whole. The composition and distribution of species in this study might be also influenced by other environmental gradients such as abiotic conditions, altitude and topography. This study is only a preliminary research, thus, further research should be made to determine whether those mentioned environmental gradients could be the source of floristic variation of tree species. Identifying these environmental gradients is essential in developing strategy to conserve and protect forest habitats. This study is beneficial in providing more information on the growth response of the mixed dipterocarp forest for the development of proper forest management. It also provides a better insight into the composition, the distribution and the main threats to their conservation.

## CONFLICT OF INTEREST

We know of no conflicts of interest associated with this publication. The authors have no conflict of interest to declare.

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**AUTHOR CONTRIBUTIONS**

SAR designed the research and performed the fieldworks and also wrote the manuscript. MAA involved partially in designing and performing the research fieldwork. SNH and NI proofread and reviewed the manuscript. MAA and NI involved in data collection and data analysis. All authors have read and approved the final version for submission.



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