Floristic Composition of Trees in the Lowland Dipterocarp Forest of Kuala Keniam, Taman Negara, Pahang, Peninsular Malaysia

Engku Azlin Rahayu Engku Ariff, Ahmad Fitri, Z., Kusin M., Nik Hazlan, N. H., Sarmin, S.N., Hashim, T.T.M.Z., Yamani, S.A.K., Syarifah Haniera, S.K., Nazip, S., Nik Norafida, N. A. & Latiff, A.

Faculty of Applied Science, Universiti Teknologi MARA Cawangan Pahang, 26400 Bandar Tun Abdul Razak, Jengka, Pahang.

Department of Biological Sciences and Biotechnology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600, Bangi, Selangor.

Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

Climate Change and Forestry Programme, Forest Biodiversity Division, Forest Research Institute Malaysia, 52109, Kepong, Selangor, Malaysia.

Corresponding author’s e-mail: engkuazlin@uitm.edu.my

Abstract. A study was conducted to determine the floristic composition and community structure of trees in lowland dipterocarp forest in Kuala Keniam, Taman Negara, Pahang. This forest is classified as a primary forest and among the oldest rainforest in the world. Five experimental plots with the dimension of 25 m x 20 m each (0.25 ha in total) had been established. The census was carried out for all trees with diameter at breast height (DBH) ≥ 5 cm and above. Species composition comprised of 244 individuals from 141 species, 94 genera and 36 families. The total number of taxa is varying across the five plots with the highest total number of families and species recorded in plot 5 with 21 and 43 taxa each. The lowest total number of families and species were recorded in plot 1 with only 14 families and 23 species. Euphorbiaceae is the most speciose family with 20 taxa and 66 individuals followed by Annonaceae with 14 taxa and 19 individuals. These two families are common in the lowland dipterocarp forests in Peninsular Malaysia. Main canopy and understorey group were recorded with the highest number of species and individuals with 52 and 45 of species and 91 and 75 of individuals, respectively. Pioneer is very rare and was only represented by a single stem of Cratoxylum formosum and Sapium baccatum. Three species, namely Koompassia malaccensis, Elateriospermum tapos and Mallotus leuckodermis were represented as the highest total number of individuals for DBH classes of ≥ 5 cm, ≥ 10 cm, ≥ 15 cm and ≥ 20 cm.

Keywords: Floristic composition, tree, primary forest, Euphorbiaceae, main canopy, understorey, Taman Negara Pahang
1. Introduction
Tropical rainforest usually received more than 200 cm of annual rainfall and the average temperature is between 20°C to 35°C. Tropical rainforest can be found in Asia, Mexico, Africa, Central America, South America, Australia and in other Pacific Islands. There are several types of tropical rainforest in Malaysia and one of them is lowland dipterocarp forests which is dominated by dipterocarp species and among the megadiverse terrestrial ecosystems. The dipterocarp forest ranges from dryland just above the sea level to an altitude of 900 m above the sea level. The dipterocarp forest can be generally classed as either lowland dipterocarp forest or hill dipterocarp forest, in which lowland dipterocarp forest is for altitude up to 300 m above sea level, and hill dipterocarp forest is for altitude of 300 m to 700 m above sea level. If however the forest is at a very high altitude i.e 750 m to 1200 m above sea level, it will be known as upper dipterocarp forest.

In general, the tropical rainforest consists of several layers of ecological groups. The structure of tropical rainforest consists of the pioneer group, successional group, emergent group, canopy group, understorey group, and treelet group. The forest structure depends greatly on the species composition. Species composition and species richness are two major components of species diversity. Species composition is defined as the identification of all different organisms that make up a complete community. It can also be defined as the relative abundance of different species or different functional group among species, and it is a fundamental key to evaluate the biological communities [1]. Species composition can also be referring to the living things that interact with each other within a given ecosystem.

Lowland dipterocarp forest in Peninsular Malaysia has been well documented on aspect of the flora compared to other forest types. The first ecological data on trees were obtained from the primary forest at Sungai Menyala Forest Reserve in Negeri Sembilan in the late 1940. The result from long recensus of trees in this forest was first published by Wyatt-Smith, [2] and the comprehensive study was reported by Manokaran and Swaine, [3]. However, Taman Negara Pahang which is covered by many types of forests including lowland dipterocarp, has been overlooked by researchers studying lowland dipterocarp forest except some studies around Kuala Keniam by Suratman et al. [4] and Suratman, [5]. The lack of research in this protected area is noteworthy. Therefore, it is hoped that with this research on the species composition of lowland dipterocarp forest with the specific aim to determine floristic composition of the tree in Kuala Keniam, it will be able to provide a useful baseline information for Kuala Keniam, National Park. This study should also be able to provide a high level of reference for further study by researchers who are interested in the study of ecology, biodiversity and forest management.

2. Materials and Methods

2.1. Study site
The study was conducted in Kuala Keniam, Pahang which is part of Taman Negara. In fact, Taman Negara with an area of 434,351 ha of primary forest is the largest protected area in Peninsular Malaysia. This huge area is straddles across three states, namely, Pahang, Kelantan and Terengganu. Taman Negara is considered as one of the oldest rain forests in Peninsular Malaysia. It is estimated to be more than 130 million years old. Several forest types which can be found in Taman Negara include lowland dipterocarp, hill dipterocarp, upper hill dipterocarp, montane oak, montane ericaceous, riparian fringe and limestone.

2.2. Methods
In this study, five plots with the dimension of 25 mx 20 m each (0.25 ha in total) were established randomly in the forested area of Kuala Keniam. All position of subplots and the squares were marked with wooden stakes. All trees with diameter ≥ 5 cm were marked and measured by using a DBH tape. Leaf specimens (fruit and flowers if present) for each tree were collected for identification. Then, the specimens were curated and processed by methods from Bridson and Forman [6] and kept in the oven.
for one week at the temperature of 60 °C. Species identification was done by using the key in the books of the local flora [7-19] and in comparison, with herbarium specimens at herbarium of Universiti Kebangsaan Malaysia (UKMB) and herbarium of Forest Research Institute Malaysia (KEP). For the classification of species groups, classification proposed by Manokaran and Swaine [3]; Kochummen et al. [20], Ahmad Fitri [21] and Ahmad Fitri et al. [22, 23, 24] were used in this study. This classification was based on the maximum height that can be achieved by a stratum of tree species in tropical rainforests and by the level of tolerance of species to the exposure of sun light.

Pioneer is a group of plants that need high exposure of sun light and will die if the tree is shaded from sun light or if there is not enough sun light exposure [3, 23]. In the successional group, the species are relatively light demanders, but are different from pioneers group in that, their seeds, if with dormancy, they do not germinate in response to the light-temperature change that accompanies gap formation [21, 23]. Emergent group is a long-lived group that needs light in the mature phase and can grow up on the top of the main canopy of primary forest up to 30 m high [20, 3]. The main canopy species group is also a relatively long-lived, which requires light on the mature phase, which forms the main canopy in primary rainforest at an altitude of 20 m and 30 m high [20, 3]. Understorey is a group of shade-tolerant species in the mature phase that forms the lower stratum in primary rainforest and have a maximum height of 20 m [20, 3]. Treelet is a group of species that are shade-tolerant which forms the lower stratum or together with a group under the canopy and have a maximum height of up to 10 m and diameter (DBH) of up to 10 cm [20].

3. Results and Discussion

3.1. Floristic composition

A total of 141 species in 94 genera and 36 families was represented by 244 individuals in the 0.25 ha plot of study area. The total number of taxa is varies across the five plots (Table 1). The highest total number of species and families was recorded in plot 5 with 21 and 43 taxa each. This was followed by plot 3 with 20 and 40 taxa each. The most speciose family is Euphorbiaceae with 20 taxa followed by Annonaceae with 14 species, Myristicaceae with nine taxa and Guttiferae with eight taxa. Table 2 shows the detailed rank of every family with the highest total number of species and percentage. Both Euphorbiaceae and Annonaceae also had the highest total number of individuals with 66 and 19, respectively. On the third rank is Leguminosae with 16 individuals followed by Myristicaceae with 14 individuals, and Dipterocarpaceae and Rubiaceae with 11 individuals each (Table 2).

| Plot | Total number of families | Total number of species | Total number of individuals |
|------|--------------------------|-------------------------|---------------------------|
| 1    | 14                       | 23                      | 23                        | 40                         |
| 2    | 20                       | 27                      | 32                        | 45                         |
| 3    | 20                       | 37                      | 40                        | 53                         |
| 4    | 18                       | 31                      | 35                        | 49                         |
| 5    | 21                       | 36                      | 43                        | 57                         |

Table 2. Species composition and total individual for all families in 0.25 ha plot at Kuala Keniam, Taman Negara, Pahang.

| Family      | Rank | Total number of species | %   | Rank | Total number of individuals | %    |
|-------------|------|-------------------------|-----|------|-----------------------------|------|
| Euphorbiaceae | 1    | 20                      | 14.18 | 1    | 66                          | 27.05 |
| Family            | No. of Genera | No. of Species | No. of Individuals | No. of Trees | No. of Stems |
|-------------------|--------------|---------------|-------------------|-------------|-------------|
| Annonaceae        | 2            | 14            | 9.93              | 2           | 19          | 7.79 |
| Myristicaceae     | 3            | 9             | 6.38              | 4           | 14          | 5.74 |
| Guttiferae        | 4            | 8             | 5.67              | 7           | 9           | 3.69 |
| Burseraceae       | 5            | 7             | 4.96              | 8           | 9           | 3.69 |
| Dipterocarpaceae  | 6            | 7             | 4.96              | 5           | 11          | 4.51 |
| Meliaceae         | 7            | 6             | 4.26              | 11          | 7           | 2.87 |
| Myrtaceae         | 8            | 6             | 4.26              | 10          | 8           | 3.28 |
| Rubiaceae         | 9            | 6             | 4.26              | 6           | 11          | 4.51 |
| Anacardiaceae     | 10           | 5             | 3.55              | 14          | 5           | 2.05 |
| Ebenaceae         | 11           | 5             | 3.55              | 15          | 5           | 2.05 |
| Leguminosae       | 12           | 4             | 2.84              | 3           | 16          | 6.56 |
| Sapindaceae       | 13           | 4             | 2.84              | 9           | 9           | 3.69 |
| Apocynaceae       | 14           | 3             | 2.13              | 17          | 3           | 1.23 |
| Lauraceae         | 15           | 3             | 2.13              | 18          | 3           | 1.23 |
| Polygalaceae      | 16           | 3             | 2.13              | 19          | 3           | 1.23 |
| Sapotaceae        | 17           | 3             | 2.13              | 12          | 7           | 2.87 |
| Ulmaceae          | 18           | 3             | 2.13              | 13          | 6           | 2.46 |
| Dilleniaceae      | 19           | 2             | 1.42              | 22          | 2           | 0.82 |
| Flacourtiae       | 20           | 2             | 1.42              | 23          | 2           | 0.82 |
| Melastomataceae   | 21           | 2             | 1.42              | 24          | 2           | 0.82 |
| Moraceae          | 22           | 2             | 1.42              | 25          | 2           | 0.82 |
| Pandaceae         | 23           | 2             | 1.42              | 20          | 3           | 1.23 |
| Sterculiaceae     | 24           | 2             | 1.42              | 26          | 2           | 0.82 |
| Verbenaceae       | 25           | 2             | 1.42              | 27          | 2           | 0.82 |
| Dichapetalaceae   | 26           | 1             | 0.71              | 30          | 1           | 0.41 |
| Icacinaceae       | 27           | 1             | 0.71              | 16          | 4           | 1.64 |
| Ixonanthaceae     | 28           | 1             | 0.71              | 28          | 2           | 0.82 |
| Lecythidaceae     | 29           | 1             | 0.71              | 31          | 1           | 0.41 |
| Loganiaceae       | 30           | 1             | 0.71              | 32          | 1           | 0.41 |
| Meliosmaceae      | 31           | 1             | 0.71              | 33          | 1           | 0.41 |
| Opiliaceae        | 32           | 1             | 0.71              | 21          | 3           | 1.23 |
| Rutaceae          | 33           | 1             | 0.71              | 34          | 1           | 0.41 |
| Symlocaceae       | 34           | 1             | 0.71              | 35          | 1           | 0.41 |
| Theaceae          | 35           | 1             | 0.71              | 29          | 2           | 0.82 |
| Tiliaceae         | 36           | 1             | 0.71              | 36          | 1           | 0.41 |
| **Total**         | **141**      | **100**       | **244**           | **100**     |              |      |

The detailed information of total number of genera, species and individuals of all families in the five plots is shown in Table 3. Compared with the previous studies of other primary tropical rainforests in Malaysia and other countries, the total number of species is considerably lower. The reason could be the census trees in the study were measured at 5 cm DBH while the previous studies started census at 1 cm DBH. Another reason is the size of plots in this study were relatively very small compared to other...
For instance, there were 820 species represented by 294 genera and 78 families of trees with a diameter ≥ 1 cm DBH in the 50-ha primary lowland dipterocarp forest plot at Pasoh Forest Reserve, Negeri Sembilan (Kochummen et al., 1990) [20]. In mixed hill dipterocarp forest of the 52-ha plot, in Lambir National Park, Sarawak, Lee et al. (2002) [25] has reported that there are 1182 species from 287 genera and 83 families of trees with a diameter ≥ 1 cm DBH. Another study in a 2 ha plot of primary forest in Bukit Timah (a coastal hill forest of Singapore), a total of 329 species were represented by 170 genera and 29 families of trees with a diameter ≥ 1 cm DBH [26].

3.2. Species group

3.2.1 All composition

In the study area, tree species were classified into seven species group viz. emergent, main canopy, understory, treelet, pioneer, successional and unclassified. The main canopy group represented the largest total number of species with 52 species (36.88%) followed by the understory group (45 species; 31.91%) and treelet group (19 species; 13.48%). The emergent group comprised of nine species (6.38%) while the successional group had six species (4.26%). The pioneer group was comprised of two species (1.42%). The unclassified group comprised of eight species (5.67%) (Table 4). It is apparent that the main canopy group recorded the highest number of stems with 91 stems with total density of 364 stems/ha (37.30%); the understory group had the second highest number of stems with 75 stems (300 stems/ha; 30.74%) followed by the treelet group that was represented by 40 stems (160 stems/ha; 16.39%) and the emergent group of 17 stems (68 stems/ha; 6.97%) (Table 4).

For comparison, a study by Manokaran and Swaine [3] in three primary forests of Peninsular Malaysia namely Bukit Lagong Forest Reserve (hill dipterocarp forest), Sungei Menyala Forest Reserve (lowland dipterocarp forest) and Pasoh Forest Reserve (lowland dipterocarp forest), they had determined that the main canopy group contributed a higher proportion of total species number compared to other ecological groups. In Bukit Lagong Forest Reserve, the main canopy group make up 47.4% of total species number, the main canopy group at the Sungei Menyala Forest Reserve formed of half or 50.4% of the total number of species, whilst the main canopy group at the Pasoh Forest Reserve accounted for 46.2% of the total number of species.

A study by Ahmad Fitri et al. [27] in the logged-over riparian forest at Hulu Sungai Sedili Besar, Johor, reported that the main canopy group recorded the highest density with 720 trees/ha followed by understory group (400 trees/ha) and treelet group (385 trees/ha). The main canopy group was dominated by Myrtaceae, Fagaceae and Euphorbiaceae. *Tristaniopsis whiteana* (main canopy group) was represented by 32 individuals. For the understory group, it was represented by the medium and small size of Euphorbiaceae, Sapotaceae, Flacourtiaeae and Sapindaceae. *Croton laevifolius* recorded the highest total number of stems (14 individuals). Emergent group was dominated by Dipterocarpaceae especially from *Dryobalanops* and *Shorea*; Leguminosae that includes *Dialium* and *Koompassia*. *Dryobalanops oblongifolia*ssp. *occidentalis* recorded the highest total number of stems with 24 individuals.

In term of density, Ahmad Fitri et al. [23] in their study in primary upper hill dipterocarp forest at Temenggor Forest Reserve, Perak have determined that the understory group was highest in the total number of stems (320 ind/ha) followed by main canopy group with 306 ind/ha. Meanwhile, Manokaran and Swaine [3] have reported that the main canopy group dominated the number of stems with the highest density at the Bukit Lagong and Sungei Menyala Forest Reserve, whilst the understory group showed the highest density at the Pasoh Forest Reserve.
| Family            | P1 | P2 | P3 | P4 | P5 |
|------------------|----|----|----|----|----|
| **Gen**          | 1  | 2  | 1  | 0  | 1  |
| **Sp**           | 1  | 3  | 1  | 0  | 1  |
| **Ind**          | 1  | 6  | 1  | 2  | 2  |
| **Gen**          | 0  | 0  | 0  | 0  | 0  |
| **Sp**           | 0  | 0  | 0  | 0  | 0  |
| **Ind**          | 0  | 0  | 0  | 0  | 0  |
| **Gen**          | 1  | 2  | 1  | 0  | 1  |
| **Sp**           | 1  | 6  | 1  | 2  | 2  |
| **Ind**          | 1  | 6  | 1  | 2  | 2  |
| **Gen**          | 0  | 0  | 0  | 0  | 0  |
| **Sp**           | 0  | 0  | 0  | 0  | 0  |
| **Ind**          | 0  | 0  | 0  | 0  | 0  |
| **Gen**          | 1  | 2  | 1  | 0  | 1  |
| **Sp**           | 1  | 6  | 1  | 2  | 2  |
| **Ind**          | 1  | 6  | 1  | 2  | 2  |
| **Gen**          | 0  | 0  | 0  | 0  | 0  |
| **Sp**           | 0  | 0  | 0  | 0  | 0  |
| **Ind**          | 0  | 0  | 0  | 0  | 0  |
| **Gen**          | 1  | 2  | 1  | 0  | 1  |
| **Sp**           | 1  | 6  | 1  | 2  | 2  |
| **Ind**          | 1  | 6  | 1  | 2  | 2  |
| **Gen**          | 0  | 0  | 0  | 0  | 0  |
| **Sp**           | 0  | 0  | 0  | 0  | 0  |
| **Ind**          | 0  | 0  | 0  | 0  | 0  |
| **Gen**          | 0  | 0  | 0  | 0  | 0  |
| **Sp**           | 0  | 0  | 0  | 0  | 0  |
| **Ind**          | 0  | 0  | 0  | 0  | 0  |
| Family            | 0  | 1  | 2  | 3  | 4  | 5  |
|-------------------|----|----|----|----|----|----|
| Rubiaceae         | 0  | 1  | 1  | 2  | 3  | 4  |
| Rutaceae          | 0  | 0  | 1  | 1  | 2  | 3  |
| Sapindaceae       | 0  | 0  | 0  | 0  | 1  | 2  |
| Sapotaceae        | 2  | 1  | 0  | 0  | 0  | 0  |
| Sterculiaceae     | 0  | 1  | 0  | 0  | 0  | 0  |
| Symplocaceae      | 0  | 0  | 0  | 1  | 2  | 3  |
| Tiliaceae         | 1  | 0  | 0  | 0  | 0  | 0  |
| Ulmaceae          | 0  | 0  | 0  | 0  | 0  | 0  |
| Verbenaceae       | 0  | 0  | 0  | 0  | 0  | 0  |
| **Total**         | 0  | 1  | 1  | 2  | 3  | 4  |

The numbers represent the count of species in each family.
Table 4. Total numbers of trees species, stems and density in different species groups in the study plots at Kuala Keniam, Taman Negara, Pahang.

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|-------------------------|--------------|-----------------------|-----------------|------------------|
| Emergent      | 9                       | 6.38         | 17                    | 6.97            | 68               |
| Main canopy   | 52                      | 36.88        | 91                    | 37.30           | 364              |
| Understorey   | 45                      | 31.91        | 75                    | 30.74           | 300              |
| Treelet       | 19                      | 13.48        | 40                    | 16.39           | 160              |
| Pioneer       | 2                       | 1.42         | 2                     | 0.82            | 8                |
| Successional  | 6                       | 4.26         | 7                     | 2.87            | 28               |
| Undetermined  | 8                       | 5.67         | 12                    | 4.92            | 48               |
| Total         | 141                     | 100          | 244                   | 100             | 976              |

3.2.2 By plot

The detailed information of all species groups in every plot is shown in Tables 5, 6, 7, 8 and 9. In plot 1, only four species group occurred, viz. emergent, main canopy, understorey and treelet. Main canopy has the highest total number of species and stems with 12 and 27 each. This was followed by understorey with six species and seven stems.

In the plot 2, both main canopy and understorey group were represented by 10 species each, but the former have higher total number of stems with 16 individuals while the latter recorded 13 individuals. The treelet group was represented by seven species and 10 individuals. In the plot 3, understorey group recorded the highest total number of species with 14 taxa (35.00%) followed by main canopy group with 11 species (27.50%) and treelet group with eight species (20.00%) (Table 7). In term of total number of stems and density, understorey group also recorded the highest total number of stems with 21 individuals (420 stems/ha) (39.62%) followed by main canopy group with 13 individuals (260 stems/ha) (24.53%) and treelet group with 10 individuals (200 stems/ha) (18.87%).

Table 5. Total numbers of trees species, stems and density in different species groups in the plot 1 at Kuala Keniam, Taman Negara, Pahang

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|-------------------------|--------------|-----------------------|-----------------|------------------|
| Emergent      | 2                       | 8.70         | 2                     | 5.00            | 40               |
| Main canopy   | 12                      | 52.17        | 27                    | 67.50           | 540              |
| Understorey   | 6                       | 26.09        | 7                     | 17.50           | 140              |
| Treelet       | 3                       | 13.04        | 4                     | 10.00           | 80               |
| Pioneer       | 0                       | 0.00         | 0                     | 0.00            | 0                |
| Successional  | 0                       | 0.00         | 0                     | 0.00            | 0                |
| Undetermined  | 0                       | 0.00         | 0                     | 0.00            | 0                |
| Total         | 23                      | 100          | 40                    | 100             | 800              |
Table 6. Total numbers of trees species, stems and density in different species groups in the plot 2 at Kuala Keniam, Taman Negara, Pahang.

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|-------------------------|--------------|-----------------------|-----------------|------------------|
| Emergent      | 2                       | 6.25         | 2                     | 4.44            | 40               |
| Main canopy   | 10                      | 31.25        | 16                    | 35.56           | 320              |
| Understorey   | 10                      | 31.25        | 13                    | 28.89           | 260              |
| Treelet       | 7                       | 21.88        | 10                    | 22.22           | 200              |
| Pioneer       | 1                       | 3.13         | 1                     | 2.22            | 20               |
| Successional  | 0                       | 0.00         | 0                     | 0.00            | 0                |
| Undetermined  | 2                       | 6.25         | 3                     | 6.67            | 60               |
| Total         | 32                      | 100          | 45                    | 100             | 900              |

In the plot 3, understorey group recorded the highest total number of species with 14 taxa (35.00%) followed by main canopy group with 11 species (27.50%) and treelet group with eight species (20.00%) (Table 7). In term of total number of stems and density, understorey group also recorded the highest total number of stems with 21 individuals (420 stems/ha) (39.62%) followed by main canopy group with 13 individuals (260 stems/ha) (24.53%) and treelet group with 10 individuals (200 stems/ha) (18.87%).

Table 7. Total numbers of trees species, stems and density in different species groups in the plot 3 at Kuala Keniam, Taman Negara, Pahang.

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|-------------------------|--------------|-----------------------|-----------------|------------------|
| Emergent      | 2                       | 5.00         | 2                     | 3.77            | 40               |
| Main canopy   | 11                      | 27.50        | 13                    | 24.53           | 260              |
| Understorey   | 14                      | 35.00        | 21                    | 39.62           | 420              |
| Treelet       | 8                       | 20.00        | 10                    | 18.87           | 200              |
| Pioneer       | 1                       | 2.50         | 1                     | 1.89            | 20               |
| Successional  | 1                       | 2.50         | 1                     | 1.89            | 20               |
| Undetermined  | 3                       | 7.50         | 5                     | 9.43            | 100              |
| Total         | 40                      | 100          | 53                    | 100             | 1060             |

Further, in plot 4, understorey group recorded the highest total number of species with 13 taxa (38.24%) followed by main canopy group with 10 species (29.41%) and treelet group with four species (11.76%) (Table 8). Successional group only represented by three species (8.82%) while emergent group only by two species (5.88%). In term of total number of stems and density, understorey group also recorded the highest total number of stems with 16 individuals (320 stems/ha) (33.33%) followed by main canopy and treelet group with 10 individuals each (200 stems/ha) (20.83%). Lastly, in plot 5, main canopy group recorded the highest total number of species with 17 taxa (39.53%) followed by understorey group with 12 species (27.91%). Both emergent and treelet group recorded five species each (11.63%) (Table 9). In term of total number of stems and density, main canopy group also recorded the highest total number of stems with 24 individuals (480 stems/ha) (42.11%) followed by understorey group with 18 individuals (360 stems/ha) (31.58%), treelet group with six individuals (120 stems/ha) (10.53%) and emergent group with five individuals (100 stems/ha) (8.77%).
Table 8. Total numbers of trees species, stems and density in different species groups in the plot 4 at Kuala Keniam, Taman Negara, Pahang.

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|------------------------|-------------|----------------------|-----------------|------------------|
| Emergent      | 2                      | 5.88        | 6                    | 12.50           | 120              |
| Main canopy   | 10                     | 29.41       | 10                   | 20.83           | 200              |
| Understorey   | 13                     | 38.24       | 10                   | 33.33           | 320              |
| Treelet       | 4                      | 11.76       | 10                   | 20.83           | 200              |
| Pioneer       | 0                      | 0.00        | 0                    | 0.00            | 0                |
| Successional  | 3                      | 8.82        | 4                    | 8.33            | 80               |
| Undetermined  | 2                      | 5.88        | 2                    | 4.17            | 40               |
| Total         | 34                     | 100         | 48                   | 100             | 960              |

Table 9. Total numbers of trees species, stems and density in different species groups in the plot 5 at Kuala Keniam, Taman Negara, Pahang.

| Species group | Total number of species | % of species | Total number of stems | % of total stems | Density (tree/ha) |
|---------------|------------------------|-------------|----------------------|-----------------|------------------|
| Emergent      | 5                      | 11.63       | 5                    | 8.77            | 100              |
| Main canopy   | 17                     | 39.53       | 24                   | 42.11           | 480              |
| Understorey   | 12                     | 27.91       | 18                   | 31.58           | 360              |
| Treelet       | 5                      | 11.63       | 6                    | 10.53           | 120              |
| Pioneer       | 0                      | 0.00        | 0                    | 0.00            | 0                |
| Successional  | 2                      | 4.65        | 2                    | 3.51            | 40               |
| Undetermined  | 2                      | 4.65        | 2                    | 3.51            | 40               |
| Total         | 43                     | 100         | 57                   | 100             | 1140             |

For each species group, at least two listed species with the highest number of individuals were shown in Table 10. In the understorey group, *Saraca cauliflora* and *Xerospermum noronhianum* were recorded with the highest number of individuals (five stems each), followed by *Diplospora malaccensis*, *Mallotus penangensis* and *Payena lucida* with four stems, respectively. *Saraca cauliflora* is the most common species in lowland and hill forest of Peninsular Malaysia and often was recorded in riverine along rocky stream banks [28].

In the treelet group, *Macaranga lowii* was recorded as the highest number of individuals (eight stems) followed by *Baccaurea brevipes* with five individuals and *Gomphandra quadrifida* with four individuals. For the main canopy group, *Elateriospermum tapos* was recorded with 16 individuals followed by *Mallotus leucodermis* (nine stems) and *Hopea pubescens* (four stems). *Elateriospermum tapos* is common throughout Peninsular Malaysia in lowland and hillsides up to 600 m a.s.l. [29]. For the emergent group, *Koompassia malaccensis* was recorded as the highest number of individuals in the group (eight stems) followed by *Shorea parvifolia* ssp. *parvifolia* with two individuals. The remaining species; viz. *Scaphium linearicarpum*, *Alstonia angustiloba*, *Anisoptera laevis*, *Dipterocarpus crinitus*, *Intsia palembanica*, *Shorea ovalis* and *Vatica bella* were represented by a single individual. Whitmore [28] reported that *I. palembanica* and *K. malaccensis* could reach 55 m high and common in lowland forest and hill forests. Additionally, *S. parvifolia* ssp. *parvifolia* is commonly found in lowland forests in Peninsular Malaysia [17, 30]. As a comparison, Kochummen et al. [20] found that 10 most abundant species were dominated by the dipterocarp including *Shorea leprosula*, *S. acuminata*, *S. parvifolia* and *S. macroptera* in the 50-ha plot at Pasoh Forest Reserve. Manokaran and Swaine [3] reported that in the Sungai Menyala Forest Reserve, the emergent group comprised of 14 dipterocarp species and some
species of Leguminosae such as Dialium platysepalum, Koompassia malaccensis, Sindora coriacea and S. echinocalyx.

For the pioneer group, only two species were recorded and represented by Cratoxylum formosum and Sapium baccatum. Both species comprised of a single stem. The occurrence of very low number of pioneers supported the status of forest around Kuala Keniam as the primary forest. According to Kochummen [31], Cratoxylum formosum is common in the secondary and primary forests of lowland and hill forests in Peninsular Malaysia. This low occurrence was quite similar for Sapium baccatum [29, 32] especially in the disturbed forest [33] and forest gaps. This species is also associated with Endospermum diademum in lowland forests that poor in dipterocarp species [34, 35]. As a comparison, Kochummen et al. [20] found that short-lived pioneer species such as Macaranga species were very rare to be observed in the primary forest of Pasoh 50 ha plot, while the pioneer group from Mallotus species was not found at all. They also reported that only 35 individual trees of Endospermum diademum were found in the 50 ha plot including 14 seedlings with ≤ 5 cm DBH.

For successional group, it was represented by Buchanania sessifolia and Pentaspadon motleyi (Anacardiaceae), Dyera costulata (Apocynaceae), Fagraea racemosa (Loganiaceae) and Nancelea officinalis and Timonius wallichianus (Rubiaceae). Except for N. officinalis, the remaining five species comprised of a single individual. All these species of successional group are common in the lowland and hill forest of Peninsular Malaysia [36, 37, 38, 39].

Table 10. List of at least two species with the highest number of individuals for four major species groups in the 0.25 ha plot at Kuala Keniam, Taman Negara, Pahang

| Species group | Species                                      | Family                  | n  |
|---------------|----------------------------------------------|-------------------------|----|
| Emergent      | Koompassia malaccensis Maing. ex Benth.      | Sterculiaceae           | 8  |
|               | Shorea parvifolia Dyer ssp. parvifolia       | Dipterocarpaceae        | 2  |
| Main canopy   | Elateriospermum tapos Blume                  | Euphorbiaceae           | 16 |
|               | Mallotus leucodermis Hook.f.                 | Euphorbiaceae           | 9  |
|               | Hopea pubescens Ridley.                      | Dipterocarpaceae        | 4  |
|               | Knema hookeriana (Wall. ex Hook.f. & Thomson) Warb. | Myristicaceae           | 3  |
|               | Alphonsea elliptica Hook.f. & Thomson        | Annonaceae              | 2  |
|               | Canarium littorale Blume                     | Burseraceae             | 2  |
|               | Cynometra malaccensis Meeuwen                | Leguminosae             | 2  |
|               | Dacryodes rostrata (Blume) H.J. Lam          | Burseraceae             | 2  |
|               | Gordonia singaporiana Wall. ex Ridl.         | Theaceae                | 2  |
|               | Ixoranthes iocosandra Jack                   | Ixonanthaceae           | 2  |
|               | Knema scortechinii (King) J. Sinclair         | Myristicaceae           | 2  |
|               | Palaquium maingayi (C.B. Clarke) King & Gamble | Sapotaceae              | 2  |
|               | Pimelodendron griffithianum (Müll.Arg.) Benth. | Euphorbiaceae           | 2  |
|               | Polyalthia sumatrana (Miq.) Kurz             | Annonaceae              | 2  |
|               | Syzygium dyerianum (King) P. Chantaranothai & J. Parn. | Myrtaceae              | 2  |
| Treelet       | Macaranga lowii King ex Hook.f.              | Euphorbiaceae           | 8  |
|               | Baccaurea brevipes Hook.f.                   | Euphorbiaceae           | 5  |
|               | Gomphandra quadrifida (Blume) Sleumer        | Icacinaceae             | 4  |
3.3. Species Composition Based DBH Classes

For DBH class of ≥ 5 cm, Elateriospermum tapos recorded the highest number of individuals (16 individuals), followed by Mallotus leucodermis (nine individuals) and Koompassia malaccensis and Macaranga lowii with eight individuals each. Meanwhile, for DBH class of ≥ 10 cm, Elateriospermum tapos has also recorded the highest number of individuals (nine) followed by Koompassia malaccensis and Mallotus penangensis with eight individuals each. Further, for class DBH of ≥ 15 cm, both E. tapos and K. malaccensis recorded the highest number of individuals (eight individuals). For DBH class of ≥ 20 cm, K. malaccensis recorded the highest total number of individuals (eight individuals) followed by E. tapos with seven individuals. Table 11 shows a list of tree species which recorded the highest number of individuals for three different DBH classes.

Table 11. List of trees species with highest number of total individuals for trees with diameter of ≥ 5 cm, ≥ 10 cm, ≥ 15 cm and ≥ 20 cm in 0.25 ha plot at Kuala Keniam, Taman Negara, Pahang

| DBH       | Species                        | Family         | n  |
|-----------|--------------------------------|----------------|----|
| ≥ 5 cm    | Elateriospermum tapos          | Euphorbiaceae  | 16 |
|           | Mallotus leucodermis           | Euphorbiaceae  | 9  |
|           | Koompassia malaccensis         | Leguminosae    | 8  |
|           | Macaranga lowii                 | Euphorbiaceae  | 8  |
|           | Baccarea brevipes              | Euphorbiaceae  | 5  |
|           | Saraca cauliflora              | Leguminosae    | 5  |

Understorey

| Species                        | Family         | n  |
|--------------------------------|----------------|----|
| Saraca cauliflora              | Leguminosae    | 5  |
| Xerospermum noronhianum        | Sapindaceae    | 5  |
| Diplospora malaccensis         | Rubiaceae      | 4  |
| Mallotus penangensis           | Euphorbiaceae  | 4  |
| Payena lucida A. DC.           | Sapotaceae     | 4  |
| Aporosa arborea                | Euphorbiaceae  | 3  |
| Aporosa microstachya           | Euphorbiaceae  | 3  |
| Giromniera parvigifolia        | Ulmaceae       | 3  |
| Horsfieldia tomentosa          | Myristicaceae  | 3  |
| Aidia densiflora               | Rubiaceae      | 2  |
| Aporosa prainiana              | Euphorbiaceae  | 2  |
| Giromniera subaequalis         | Ulmaceae       | 2  |
| Lansium domesticum             | Meliaceae      | 2  |
| Neoscoretchnia kingii          | Euphorbiaceae  | 2  |
Xerospermum noronhianum (Blume) Blume Sapindaceae 5
Diplospora malaccensis Hook.f. Rubiaceae 4
Gomphandra quadrifida (Blume) Sleumer Icacinaceae 4
Hopea pubescens Ridl. Dipterocarpaceae 4
Mallotus penangensis Müll.Arg. Euphorbiaceae 4
Payena lucida A. DC. Sapotaceae 4

≥ 10 cm Elateriospermum tapos Blume Euphorbiaceae 9
Koompassia malaccensis Maing. ex Benth. Leguminosae 8
Mallotus penangensis Müll.Arg. Euphorbiaceae 8
Hopea pubescens Ridl. Dipterocarpaceae 4
Xerospermum noronhianum (Blume) Blume Sapindaceae 4

≥ 15 cm Elateriospermum tapos Blume Euphorbiaceae 8
Koompassia malaccensis Maing. ex Benth. Leguminosae 8
Mallotus leucodermis Hook.f. Euphorbiaceae 5
Xerospermum noronhianum (Blume) Blume Sapindaceae 4

≥ 20 cm Koompassia malaccensis Maing. ex Benth. Leguminosae 8
Elateriospermum tapos Blume Euphorbiaceae 7
Mallotus leucodermis Hook.f. Euphorbiaceae 3
Xerospermum noronhianum (Blume) Blume Sapindaceae 3

4. Conclusion
This study showed that the pristine lowland dipterocarp forest around Kuala Keniam in Taman Negara (Pahang) harbours more than 100 tree species in the relatively small plots of 0.25 ha. The total number of species varies across the five plots with the highest total number of species was recorded in plot 5 with 43 species while the lowest total number of species was recorded in plot 1 with only 23 species. The occurrence of Euphorbiaceae as the most speciose family was expected and also reported in other lowland dipterocarp forests in Peninsular Malaysia. For the species group, main canopy and understorey groups recorded the highest number of species with 52 and 45 of species, respectively. The occurrence of pioneer species is very rare and only represented by two species namely Cratoxylum formosum and Sapium baccatum which shows that this forest is not disturbed by human activities and without having large forest gaps. The present study gave the preliminary data of tree species in the primary lowland forests for diameter ≥ 1 cm DBH is needed in the future to obtain more valuable floristic data.

5. Acknowledgement
The authors would like to express their sincere appreciation to the Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA, Shah Alam and to PERHILITAN for their generous funding and valuable technical support during the scientific expedition. The authors also would like to thank the curators of the following herbaria; L, KEP and UKMB for allowing the examination of their specimens.
References

[1] Billheimer, D., Guttrop, P., & Fagan, W. F. 2001. Statistical interpretation of species composition. Journal of the American Statistical Association, 96(456), 1205–1214.

[2] Wyatt-Smith, J. 1966. Ecological studies on Malayan forests. I. Composition and dynamic studies in lowland evergreen rain forest in two 5-acre plots in Bukit Lagong and Sungei Menyala Forest Reserves and in two half-acre plots in Sungei Menyala Forest

[3] Manokaran, N. & Swaine, M.D. 1994. Population Dynamics of Trees in Dipterocarp Forests of Peninsular Malaysia. Kepong: Forest Research Institute Malaysia.

[4] Suratman, M.N., Mazlin, K., Zakaria, S.A.K.Y., Kamarudin, S., Mansur, A., Shahril Anuar, B. 2010. Stand structure and species diversity of Keniam forest, Pahang National Park. International Conference on Science and Social Research (CSSR 2010).

[5] Suratman, M.N. 2012. Tree Species Diversity and Forest Stand Structure of Pahang National Park, Malaysia. In: Lameed, G.A., (ed.). Biodiversity Enrichment in a Diverse World, pp. 473-492. Rijeka: In Tech.

[6] Bridson, D. & Forman, L. 1992. The Herbarium Handbook. Boston: WCB/McGraw-Hill.

[7] Corner, E. J. H. 1988. Wayside Trees of Malaya. Volumes 1 & 2. Third Edition. Kuala Lumpur: The Malayan Nature Society.

[8] Kiew, R., Chung, R.C.K., Saw, L.G., Soepadmo, E. & Boyce, P. 2010. Flora of Peninsular Malaysia. Vol. 1. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[9] Kiew, R., Chung, R.C.K., Saw, L.G., Soepadmo, E. & Boyce, P. 2011. Flora of Peninsular Malaysia. Vol. 2. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[10] Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. 2012. Flora of Peninsular Malaysia. Vol. 3. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[11] Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. 2013. Flora of Peninsular Malaysia. Vol. 4. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[12] Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. 2015. Flora of Peninsular Malaysia. Vol. 5. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[13] Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. 2017. Flora of Peninsular Malaysia. Vol. 6. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[14] Kiew, R., Chung, R.C.K., Saw, L.G. & Soepadmo, E. 2018. Flora of Peninsular Malaysia. Vol. 7. Series II: Seed Plant. Kepong: Forest Research Institute Malaysia.

[15] Ng, F. S. P. 1978a (ed.). Tree Flora of Malaya. Volume 3. Kuala Lumpur: Longman.

[16] Ng, F. S. P. 1989 (ed.). Tree Flora of Malaya. Volume 4. Petaling Jaya: Longman.

[17] Symington, C.F. 2004. Foresters’ Manual of Dipterocarps. Second edition revised by Ashton, P.S. & Appanah, S. (2004). Malayan Forest Record No. 16. Kepong: Forest Research Institute Malaysia.

[18] Whitmore, T. C. 1972a (ed). Tree Flora of Malaya. Volume 1. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[19] Whitmore, T. C. 1973a (ed). Tree Flora of Malaya. Volume 2. Kuala Lumpur: Longman.

[20] Kochummen, K., M., La Frankie, J. V. & Manokaran, 1990. Floristic composition of Pasoh Forest Reserve, a Lowland Rain Forest in Peninsular Malaysia. Journal of Tropical Forest Science 3(1) : 1-13.

[21] Ahmad Fitri, Z. 2013. Community structure, species diversity and relationship of tree communities with soil factors in upper hill dipterocarp forest of Perak state, Peninsular Malaysia. M.Sc. Thesis. Universiti Kebangsaan Malaysia (unpublished).

[22] Ahmad Fitri, Z. Nik Hazlan, N.H., Khairil, M., Mohamad Murshidi, Z., Mohamad Sobre, Z. & Latiff, A. 2014. Komposisi spesies pokok di Hutan Simpan Gunung Tebu, Terengganu. In: Abd Rahman, A.R., Mohs Nasir, A.H., Azmi, N., Nor Hasliza, M.B. & Latiff, A. (eds.). Hutan Simpan Gunung Tebu, Terengganu: Pengurusan Hutan, Persekutuan Fizikal dan Kepelbagaian Biologi, pp. 271-284. Kuala Lumpur: Jabatan Perhutanan Semenanjung Malaysia.
[23] Ahmad Fitri, Z. Nizam, M.S., Latiff, A., Abd. Rahman, K., Serafina Christine, F. & Shamsudin, I. 2017. Floristic composition and biomass of trees in Temengor Forest Reserve, Perak, Peninsular Malaysia. *The Malaysian Forester* 80 (2) : 178-197.

[24] Ahmad Fitri, Z., Wan Norilani, W. I., Wan Juliana, W. A., Mohamad Ruzi, A. R. & Mohd Nizam, M. S. 2018. Species composition and community structure of trees in a lowland dipterocarp forest. In: Haja Maideen Kader Maideen, Wan Juliana Wan Ahmad & Mohamad Ruzi Abdul Rahman (eds.). *A Natural Heritage: The Flora and Fauna of Universiti Kebangsaan Malaysia*, pp. 44-56. Bangi: Penerbit UKM.

[25] Lee, H. S., Davies, S. J., LaFrankie, J. V., Tan, S., Itoh, A., Yamakura, T., & Ashton, P. S. 2002. Floristic and structural diversity of 52 hectares of mixed dipterocarp forest in Lambir Hills National Park, Sarawak, Malaysia. *Journal of Tropical Forest Science* 14 : 379-400.

[26] Lum, S. K. Y., Lee, S. K., & LaFrankie, J. V. 2004. Bukit Timah Forest dynamics plot, Singapore. In, Losos, E.C., Leigh Egbert Giles, J. (eds.). *Tropical Forest Diversity and Dynamism: Findings from a Large-Scale Plot Network*, pp. 464-473. Chicago: University of Chicago Press.

[27] Ahmad Fitri, Z., Muhamad Firdaus, A. S., Norazlinda, M., Nizam, M.S., Muhammad Rasul, A. H., Muhamad Ridwan, H., Nik Norafida, N. A., Nik Hazlan, N. H. Mohamad Sobre, Z., Mohamad Murshidi, Ahmad Firdaus Z. & Latiff, A. 2020. Species composition, community structure and diversity of trees in a logged-over riparian forest at Hulu Sungai Sedili Besar, Johor, Malaysia. *Malayan Nature Journal* 72(3) : 295-309.

[28] Whitmore, T. C. 1972b. Leguminosae. In: Whitmore, T. C. (ed.). *Tree Flora of Malaya* 1 : 237-304. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[29] Whitmore, T. C. 1973c. Euphorbiaceae. In: Whitmore, T. C. (ed.). *Tree Flora of Malaya* 2 : 34-136. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[30] Chua, L. S. L., Suhaida, M., Hamidah, M. & Saw, L. G. 2010. *Malaysia Plant Redlist: Peninsular Malaysian Dipterocarpaceae*. Research Pamphlet No. 129. Kepong: Forest Research Institute Malaysia.

[31] Kochummen, K.M. 1973a. Hypericaceae. In: Whitmore, T. C. (ed.). *Tree Flora of Malaya* 2 : 248-252. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[32] Esser, H.-J. 1999. A partial revision of the Hippomaneae (Euphorbiaceae) in Malesia. *Blumea* 44 : 149–215.

[33] van Welzen, P. C. (ed.). 2020. *Flora Malesiana - Euphorbiaceae*. Naturalis Biodiversity Centre, Leiden, www.nationaalherbarium.nl/euphobrs.

[34] Wyatt-Smith, J. 1963. Manual of Malayan silviculture for inland forest. Second Edition. Volumes 1 & 2. *Malayan Forest Records* No. 23. Kepong: Forest Research Institute Malaysia.

[35] Wyatt-Smith, J. 1999. *Pocket Check List of Timber Trees*. Third revision by Kochummen, K.M. Malayn Forest Records. No. 17. Kepong: Forest Research Institute Malaysia.

[36] Kochummen, K.M. 1989. Anacardiaceae. In: Ng, F. S. P. (ed.). *Tree Flora of Malaya* 4 : 9-57. Petaling Jaya: Longman Malaysia Sdn. Berhad.

[37] Whitmore, T. C. 1973b. Apocynaceae. In: Whitmore, T. C. (ed.). *Tree Flora of Malaya* 2 :3-24. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[38] Kochummen, K.M. 1973b. Loganiaceae. In: Whitmore, T. C. (ed.). *Tree Flora of Malaya* 2 : 267-275. Kuala Lumpur: Longman Malaysia Sdn. Berhad.

[39] Wong, K. M. 1989. Rubiaceae. In: Ng, F. S. P. (ed). *Tree Flora of Malaya* 4 : 324-425. Petaling Jaya: Longman Malaysia Sdn. Berhad.