Species diversity of pteridophytes in oil palm plantations at Segamat, Johor

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Abstract. Species composition, diversity and richness of pteridophytes were observed in three oil palm plantations of different age and management histories at Segamat, Johor using random sampling method. A total of 3762 individuals of pteridophytes consisting of 32 species belonging to 13 families from 20 genera were identified and recorded. Family Polypodiaceae, genera *Microsorum* and family Davalliaceae, genera *Davallia* contributed to the highest richness of species and were commonly found within the study area. The diversity index represented by Shannon Index, H', is 2.51 whereas the computed evenness index is 0.72 for the overall pteridophytes species indicating a relatively high species distribution within the monoculture system. The species richness in Kg. Sri Rahmat oil palm plantation was found higher than Kg. Logah and Felda Medoi oil palm plantation with 2.15, 2.10 and 2.09 respectively. From the total recorded species of pteridophytes, the highest diversity is observed at the Kg. Sri Rahmat (H'=2.07) followed by Kg. Logah (H'=1.81) and Felda Medoi (H'=1.79). At Kg. Sri Rahmat, the species evenness is nearly even (EH=0.73) whereas at Kg. Logah and Felda Medoi, the species evenness was less significant different (EH=0.66 and EH=0.65). The type of fertilizer used, frequency of herbicide application and pruning activity at Kg. Sri Rahmat could potentially affect the diversity of pteridophytes species in the plantation. This highlights the potential of oil palm plantations owned by smallholders as an ecosystem support for the diversity of pteridophytes species. However, this may vary with different plantation age and management history.

1. Introduction

Oil palm (*Elaeis guineensis*) is the main producer of vegetable oil in the tropical countries that developed across over than 13.5 million hectares [1]. It is commonly distributed at tropical, low-lying areas, high rainfall, a region naturally occupied by moist tropical forest which the most biologically diverse terrestrial ecosystem on Earth [2]. However, regardless of its effectiveness, the industry has had generous environmental impacts, generally in light of the fact that nearly all oil palm development as yet has come to the detriment of natural forest [3]. Southeast Asia has perhaps the most undertakes deforestation anywhere in the tropics, during the 1990s and 2000s with 1.4% yearly forest loss [4]. Malaysia, Sumatra and Java had been lost almost 70% of forest across by 2010 [5]. It also drastically affected the biodiversity of many plant groups, including the pteridophytes. Recently in Malaysia, 5.74
millions of hectares of land is under oil palm cultivation which is 745,630 ha in Johor and 34,997.27 ha of oil palm in Segamat, Johor [6].

Pteridophytes were the dominating vegetation of the earth all through the Carboniferous Period [7]. Nowadays, the distribution of the pteridophytes assumes a convincing part to form the strong carpet flora and undercover vegetation are in the tropical, subtropical, and remote tropical islands and in different natural surroundings or even in more profound rainforests [8]. The pteridophytes are ecologically strong natural complement of a rich forest [9, 10]. Living pteridophytes are virtually subdivided into (true) ferns and fern allies. Comprehensively there are about 12,000 species of pteridophytes [11], of which about 97% are ferns and 3% the fern allies or Lycophytes. With around 12,000 named species of pteridophytes around the world, the assortment to be found among them is remarkable in its variety of forms, textures, and even colours [12].

The number of taxa of pteridophytes that have recorded in The Plant List possess 48 families and 587 genera [13]. These lists encompass 47,439 scientific plant names of species rank for the pteridophytes. Of these 10,620 are accepted species names. About 4400 species are known and 1165 species have been recorded from the tropical rainforest of Malaysia in South East Asia [14-16]. From a study by Boonkerd et al. [17] on pteridophytes, 19 species of pteridophytes had been identified such as Adiantum latifolium, Taenitis blechnoides and Vittaria elongata. Another pteridophytes species found in oil palm plantation are Nephrolepis biserrata and Goniophlebus verrucosum. Pteridophytes are vascular plants and have leaves (known as fronds), roots and occasionally true stems, and tree ferns have full trunks. In addition, in the largest species of ferns, fronds can extend in the range of six meters in long. They differ from seed plants because they do not have either seeds or flowers, as they only reproduce via spores.

Most studies on pteridophytes often do not utilize ecological approaches or perspective to discuss the pteridophytes abundance in oil palm plantations. This is crucial, since the role of diverse plant communities in supporting species in different groups may significantly affect more extensive plantation biodiversity [18]. Studies have likewise researched the impacts of epiphytes in oil palm plantation and discovered no deficiency of palm oil yield except for sake for biodiversity where epiphytes are available [19]. However, there is limited data on the species composition and diversity of pteridophytes in oil palm plantations owned by smallholders with different management history at Segamat, Johor. Hence, this study aims to identify the species composition, diversity, richness and abundance of pteridophytes (focusing on ferns and ferns allies) in oil palm plantations owned by smallholders at Segamat, Johor.

2. Materials and Methods

2.1. Study area

The sampling of pteridophytes species was conducted in the middle of July 2019 at three oil palm plantations at Segamat, Johor (2°30’N, 102°50’E). The three oil palm plantations were Kg. Logah (2°31’36.50”N, 102°50’58.76”E), Kg. Sri Rahmat (2°28’38”N, 102°49’ 36.78”E) and Felda Medoi (2°31’47.22”N, 102°53’3.95”E) (Figure 1). The size of sampling area, age of plantation, management, and treatment history of all three plantations are depicted in Table 1.
Table 1. Size of sampling area, age, management and treatment of three oil palm plantations.

| Oil Palm Plantation | Kg. Logah | Kg. Sri Rahmat | Felda Medoi |
|---------------------|-----------|----------------|-------------|
| Sampling area (acres) | 3         | 2              | 8           |
| Age (years old)     | 19        | 10             | 9           |
| Management (Herbicide) | 3x in a year | 2x in a year | 4x in a year |
| Management (Fertilizer) | 3x in a year | 3x in a year | 4x in a year |
| Type of Fertilizer | Organic     | 2x organic & Chemical |
| Treatment (Pruning) | 2x in a year | 1x neutral | 3x in a year |

2.2. Sampling design
Random sampling was carried out within ten 10 m × 10 m quadrats at each plantation to ensure uniformity of data collected. Four oil palm trees were chosen randomly within each quadrat giving a total of 40 oil palm trees chosen at each plantation (4 oil palm trees × 10 quadrats × 3 plantations) (Figure 1). At each plantation, all pteridophytes from ground level to 1.5 meter of heights were taken into consideration. General observation on any species of pteridophytes on oil palm trunks that were above 1.5-meter height and surrounding the quadrat was done as supporting information. The coordinates for each quadrat chosen was recorded using a GPS (Garmin 64s, USA).

2.3. Sample collection, preservation and identification
Pteridophytes samples were collected, carefully tagged and labelled (i.e. date and location of sampling) for herbarium preparation and identification. The plant samples were cut using secateurs for a clean cut of the stem. The samples then were stacked between sheets of newspaper, placed in plastic bags and preserved with 70% ethanol (HmBG Chemicals, Malaysia). The samples from the field were then unpacked from the newspaper containing 70% ethanol, restacked between sheets of other newspaper to remove moisture and pressed using cardboard and wooden frame.

The plant samples were then brought to the biochemistry and microbiology laboratory, Universiti Malaysia Kelantan and oven dried (between 45°C to 50°C) for three to seven days depending on the condition of the sample to ensure that the sample retains its color and does not become brittle or scorched. The plant specimens were mounted on the A3 paper after drying and clearly labelled by the name and classification of the plant as for all collection data following herbarium specimen’s storage guideline by the Museum of Natural Resources, Universiti Malaysia Kelantan.

All specimens were pre-identified using PictureThis application (Glority Global Group Ltd., China) that allowed identification of plant simply by photographing and uploading the photos on the app. The specimens were also identified using botanical books such as books of Flora of Peninsular Malaysia.
Series 1 and Volume 1 [20], and Ferns of Malaysia in Colour [21] while the nomenclature was according to the International Plant Names Index (IPNI). All identified species were verified by Dr. Radhiah Zakaria, botanist expert from Faculty of Public Health, Muhammadiyah University of Aceh.

2.4. Data analysis

2.4.1. Diversity indices.

i. Shannon Diversity Index (H') [22] was used to characterize species diversity in a community, wherein both the species richness which is number of species and species abundance that number of individuals within the same species are include in the function as in equation (1),

\[ H' = - \sum_{i=1}^{S} (p_i \ln p_i) \]  \hspace{1cm} (1)

Where,
\( H' \) = The Shannon diversity index
\( p_i \) = Proportion \( n/N \) of individuals of one particular species found \( n \) divided by the total number of individuals found \( N \)
\( S \) = Numbers of species encountered

ii. Evenness Index is an important property of all ecological communities and defined as “the degree to which the abundances are equal among the species present in a sample or community” [23] as in equation (2),

\[ E_H = \frac{H}{H_{max}} = \frac{H'}{\ln S} \]  \hspace{1cm} (2)

Where,
\( E_H \) = the Shannon Evenness Index
\( H' \) = the Shannon Diversity Index
\( S \) = the species Diversity

iii. Sørensen Similarity Index is used to compare the similarity of two community samples in terms of their species content [24] as in equation (3),

\[ \text{Sørensen’s coefficient (Cs)} = \frac{a}{a + b + c} \]  \hspace{1cm} (3)

Where,
\( a \) = the number of species common to both communities
\( b \) = the number of species in community 1
\( c \) = the number of species in community 2

2.4.2. Richness index. Species richness is a measure for the total number of the species in a community. The Margalef index is highly sensitive to sample size although it tries to compensate for sampling effects [25] was calculated as in equation (4) to measures species richness,

\[ d = \frac{S - 1}{\ln N} \]  \hspace{1cm} (4)

Where;
\( S \) = the number of species
\( N \) = the total number of individuals in the sample
2.4.3. Abundance parameter.

i. Density = \frac{\text{number of individual of species in sampling unit}}{\text{total number of sampling unit studies}} = \frac{n_i}{A} \quad (5)

Where,

\( n_i \) = number of individuals of a species in sampling unit

\( A \) = total number of sampling unit studied

ii. Frequency or proportion of sampling units such as the quadrat or field that contains the species was determined as in equation (6),

\[
\text{Frequency} = \frac{\text{total of quadrant in which species occur}}{\text{total number of quadrant studied}} \times 100 = \frac{j_i}{k} \quad (6)
\]

Where,

\( j_i \) = number of quadrant in which species occur

\( k \) = total number of quadrant studied

2.4.4. Importance value index (IV\( i \)). The Importance Value Index (IV\( i \)) is a significant parameter in any ecological assessment. It is an indicator of ecological success of the species and can be calculated from equation (7), (8) and (9). IV\( i \) of the plant species was determined as the sum of the relative frequency and relative density [26],

i.

\[
\text{IV}^i = \frac{\text{relative density} + \text{relative frequency}}{2} \quad (7)
\]

ii.

\[
\text{Relative density} = \frac{\text{density of species}}{\text{total density of all species}} \times 100 \quad (8)
\]

iii.

\[
\text{Relative frequency} = \frac{\text{frequency of species}}{\text{total frequency of all species}} \times 100 \quad (9)
\]

3. Results and Discussion

3.1. Species composition of pteridophytes in different aged oil palm plantations

A total of 3762 individuals of pteridophytes that represent 32 different species of pteridophytes from 13 families had been collected from all three oil palm plantations namely Kg. Logah, Kg. Sri Rahmat and Felda Medoi, respectively (Table 2).

From Table 2, pteridophytes species from family Polypodiaceae contributed the highest number of genus and species with seven genera and ten species, followed by Nephrolepidaceae with one genus and five species and Davalliaceae with one genus and four species each. This variation in species found showed that there was various diversity of pteridophytes species inhibiting the three Segamat oil palm plantations due to different adaptation of the species to the environment, age and management.

The data obtained in Table 3, showed the family of Polypodiaceae was dominant at Kg. Logah oil palm plantation with a total of five species recorded and 15.63% of the species found. Kg. Sri Rahmat oil palm plantation recorded a total of ten families. From that number, the highest contributor of pteridophytes species were from family Polypodiaceae, Nephrolepidaceae and Blechnaceae with 12.5%, 9.38% and 6.25% respectively. At Felda Medoi, Family Polypodiaceae was dominant as it recorded five species with percentage of 15.63% that were found followed by Davalliaceae with four species and Nephrolepidaceae with two species that were found with percentage of 12.5% and 6.25% respectively. From this study, family Polypodiaceae dominated all three oil palm plantations. This is in line with the findings that the spikes of the family Polypodiaceae like habitat disturbed, so it might be better if its lives in a managed environment of
the human being in the natural environment [27]. Plus, this may be because of moderately undisturbed plantation of less management practice like weed the management utilizing herbicide [28].

**Table 2.** List of pteridophytes species and number of individuals in all three oil palm plantations.

| Family           | Genus          | Species                      | No. of individuals |
|------------------|----------------|------------------------------|--------------------|
| Aspleniaceae     | *Asplenium*    | *Asplenium nidus*            | 5                  |
|                  |                | *Asplenium tenerum*          | 21                 |
| Blechnaceae      | *Blechnum*     | *Blechnum indicum*           | 24                 |
|                  |                | *Stenochlaena*               | 300                |
| Davalliaceae     | *Davallia*     | *Davallia denticulata*       | 822                |
|                  |                | *Davallia solida*            | 239                |
|                  |                | *Davallia trichomanoides*    | 61                 |
|                  |                | *Davallia repens*            | 7                  |
| Dennstaedtiaceae | *Microlepia*   | *Microlepia speluncae*       | 3                  |
| Gleicheniaceae   | *Dicranopteris*| *Dicranopteris linearis*     | 33                 |
| Lindsaeaceae     | *Lindsaea*     | *Lindsaea ensifolia*         | 3                  |
| Lycopodiaceae    | *Lycopodiella* | *Lycopodiella cernua*        | 340                |
| Nephrolepidae    | *Nephrolepis*  | *Nephrolepis auriculata*     | 21                 |
|                  |                | *Nephrolepis radicans*       | 21                 |
|                  |                | *Nephrolepis biserrata*      | 235                |
|                  |                | *Nephrolepis cordifolia*     | 291                |
|                  |                | *Nephrolepis brownii*        | 10                 |
| Polypodiaceae    | *Belvisia*     | *Belvisia mucronata*         | 6                  |
|                  | *Drynaria*     | *Drynaria quercifolia*       | 14                 |
|                  | *Goniophlebium*| *Goniophlebium subauriculatum*| 7                 |
|                  |                | *Goniophlebium sp.*          | 63                 |
|                  |                | *Goniophlebium percussum*    | 23                 |
|                  | *Microsorum*   | *Microsorum scolopendria*    | 688                |
|                  | *Prymatopteris*| *Prymatopteris lacinia*      | 19                 |
|                  | *Pyrrosia*     | *Pyrrosia lanceolata*        | 121                |
|                  |                | *Pyrrosia longifolia*        | 46                 |
|                  | *Selliguea*    | *Selliguea lanciniata*       | 34                 |
| Pteridaceae      | *Acrostichum*  | *Acrostichum sp.*            | 1                  |
| Schizaeaceae     | *Lygodium*     | *Lygodium longifolium*       | 23                 |
| Thelypteridaceae | *Christella*   | *Christella parasatica*      | 5                  |
| Vittariaceae     | *Vittaria*     | *Vittaria elongata*          | 17                 |
|                  |                | *Vittaria ensiformis*        | 259                |

|               | 13  | 20  | 32  | 3762 |

Table 3. The percentage of species with dominant family of pteridophytes recorded at different aged of all three oil palm plantations at Segamat, Johor.

| Plantation/Age | Family            | Species | Percentage (%) |
|----------------|-------------------|---------|----------------|
| Kg. Logah (19 years old) | Polypodiaceae | 5       | 15.63          |
|                 | Davalliaceae      | 2       | 6.25           |
|                 | Vittariaceae      | 2       | 6.25           |
| Kg. Sri Rahmat (10 years old) | Polypodiaceae | 4       | 12.5           |
|                 | Nephrolepidaceae  | 3       | 9.38           |
|                 | Blechnaceae       | 2       | 6.25           |
| Felda Medoi (9 years old) | Polypodiaceae | 5       | 15.63          |
|                 | Davalliaceae      | 4       | 12.5           |
|                 | Nephrolepidaceae  | 2       | 6.25           |

3.2. Diversity analysis

3.2.1. Shannon-Diversity (H') and Shannon-Evenness (E_H) indices. In Table 4, the overall species distribution (H’) of pteridophytes was relatively moderate (H’=2.51, Hmax=3.47). A highly diverse (H’=2.07, Hmax=2.83) species of pteridophytes was recorded at the oldest plantation, Kg. Sri Rahmat. This is followed by Kg. Logah (H’=1.81, Hmax=2.77) and Felda Medoi (H’=1.79, Hmax=2.71) plantations indicating a less diverse pteridophytes species inhibiting slightly younger plantations as compared to Kg. Sri Rahmat plantation.

Table 4. Shannon-Diversity Index (H’) and Shannon-Evenness Index (E_H) of pteridophytes species recorded at all three oil palm plantations at Segamat, Johor.

| Oil Palm Plantation | Shannon-Index (H’) | Hmax | Shannon-Evenness (E_H) |
|---------------------|--------------------|------|------------------------|
| Overall             | 2.51               | 3.47 | 0.72                   |
| Kg. Logah           | 1.81               | 2.77 | 0.65                   |
| Kg. Sri Rahmat      | 2.07               | 2.83 | 0.73                   |
| Felda Medoi         | 1.79               | 2.71 | 0.66                   |

The E_H ranges from 0 (when one species is dominant) to 1 (when all species are equally abundant). The overall species distribution at all three oil palm plantations was E_H = 0.72, indicating that there were relatively high evenness communities or well distribution of pteridophytes species (Table 2). This expressed how evenly the individuals in a community were distributed among the different species of pteridophytes [29] in addition to the calculated value of species diversity index [30]. The number of individuals for each pteridophyte species was rather high and commonly found within most plots. Kg. Sri Rahmat recorded the highest species evenness (0.73) that includes common species such as Stenochlaena palustris, Davallia denticulata, Nephrolepis cordifolia and Microsorum scolopendria. In contrast, Kg. Logah (0.65) and Felda Medoi (0.66) had lower number of individuals and only two and three species that occurred in all plots but moderately high evenness among the species within the two oil palm plantations respectively.

3.2.2. Sorensen Similarity Index. The similarity index was calculated to determine the similarity index between two locations where indices closer to 1 show a higher degree of similarity between sites while indices closer to 0 show greater dissimilarity [31]. Based on Table 5, all three plantations showed less similarity among the family, genus as well as species level of pteridophytes.
Table 5. Sørensen Similarity Index (Cs) of pteridophytes recorded at different aged of all three oil palm plantations at Segamat, Johor.

| Location/Site        | Family | Genus | Species |
|----------------------|--------|-------|---------|
| Kg. Logah - Kg. Sri Rahmat | 0.42   | 0.39  | 0.30    |
| Kg. Sri Rahmat - Felda Medoi | 0.37   | 0.33  | 0.30    |
| Kg. Logah - Felda Medoi | 0.43   | 0.40  | 0.28    |

For Kg. Logah and Kg. Sri Rahmat similarity index calculated was 0.30. The seven families, eight genus and seven species that were similar were *S. palustris*, *D. denticulata*, *Dicranopteris linearis*, *Lycopodiella cernua*, *Goniophlebium sp.*, *M. scolopendria* and *Vittaria elongata*. For Kg. Sri Rahmat and Felda Medoi, there were also a total of seven similar species which were *S. palustris*, *D. denticulata*, *Davallia trichomanoides*, *Nephrolepis biserrata*, *N. cordifolia*, *Goniophlebium sp.*, and *M. scolopendria*. Thus, resulting that the similarity index of species was highest among other plantation with value of 0.30 due to the age of both plantations were less different. The similarity index of species between Kg. Logah and Felda Medoi calculated was 0.28 showing that it was the least similar with another two location pairs as there were only six similar species found in both locations which were *S. palustris*, *D. denticulata*, *Davallia solida*, *Goniophlebium sp.*, *M. scolopendria* and *Vittaria ensiformis*.

3.3. Species richness

Table 6 shows the richness index of pteridophytes recorded in the study area. Species richness is a proportion of the number of species found in a sample where larger values show the likelihood of discovering more species within the area [32].

Table 6. Richness Index of pteridophytes recorded at different aged of all three oil palm plantations at Segamat, Johor.

| Plantation/Age | Richness Index (d) |
|---------------|-------------------|
| Overall       | 3.73              |
| Kg. Logah     | 2.10              |
| Kg. Sri Rahmat| 2.15              |
| Felda Medoi   | 2.09              |

The overall species richness for all three oil palm plantations was 3.73. This might be due to low plants adaptability to environmental conditions since the number of pteridophytes species are not evenly associated with adaptation patterns of each species [33]. The highest value of species richness was observed in Kg. Sri Rahmat (2.15) followed by Kg. Logah (2.10) and the lowest was observed in Felda Medoi (2.09). In addition, the number of individuals for species recorded at Kg. Sri Rahmat was higher than the other two plantations and most Pteridaceae and Polypodiaceae family were found in sheltered areas. Kg Sri. Rahmat plantation has low light intensity due higher canopy cover since pruning was only done once in a year. Light intensity influences the air humidity, causing few ferns grow ideally in high air humidity (e.g. ferns from Polypodiopsida class) [34]. The most common ferns on oil palm trunk was *M. scolopendria* with occurrence of 688 spots on 120 trunks.

3.4. Abundance parameter

Species abundance depicts the number of individuals on the similar sample plot [35]. There are quite a few different indices (frequency, density, cover and biomass) for measuring abundance depending among the others on the target species, the habitat type, the aim of the study and the economic resources [36]. Density (d) measures the number of target species per given area whereas frequency
reflects both a species' presence or absence and how much it is distributed within a community. In Table 7, the density and frequency of *D. denticulata* (46.8, 100%) was highest in Kg. Logah plantation. In Kg. Sri Rahmat, the highest density and frequency recorded were *M. scolopendria* (33.5, 100%) whereas in Felda Medoi, *N. biserrata* (16.2, 100%) has the highest species density recorded. The higher the density value, the more abundant number of the species present in that area. In contrast, *V. ensiformis* in Kg. Logah and *M. scolopendria* in Felda Medoi only recorded 9 occurrences.

**Table 7.** Three highest value of density and frequency of pteridophytes species at all three oil palm plantations.

| Plantation  | Species               | No of Individuals | Occurrence | Density | Frequency (%) |
|-------------|-----------------------|-------------------|------------|---------|---------------|
| Kg. Logah   | *Davallia denticulata*| 468               | 10         | 46.8    | 100           |
|             | *Vittaria ensiformis* | 226               | 9          | 22.6    | 90            |
|             | *Microsorum scolopendria* | 224            | 10         | 22.4    | 100           |
| Kg. Sri Rahmat | *Microsorum scolopendria* | 335           | 10         | 33.5    | 100           |
|             | *Nephrolepis cordifolia* | 289           | 10         | 28.9    | 100           |
|             | *Stenochlaena palustris* | 284           | 10         | 28.4    | 100           |
| Felda Medoi | *Nephrolepis biserrata* | 162           | 10         | 16.2    | 100           |
|             | *Microsorum scolopendria* | 129           | 9          | 12.9    | 90            |
|             | *Davallia denticulata* | 121             | 10         | 12.1    | 100           |

3.5. Importance value index

Importance value of each species was calculated by adding all the relative values of RD, RF [37, 38]. The communities were named after the three leading species having the highest importance values. Relative density (Rd) reveals the abundance of species in term of number of individual. It is expected that certain species will be more significant in term of the two parameters.

**Table 8:** Relative density (Rd), Relative frequency (Rf) and importance value index (IVi) of dominant species recorded at different aged of all three oil palm plantations at Segamat, Johor.

| Plantation   | Species              | Rd (%) | Rf (%) | IVi (%) |
|--------------|----------------------|--------|--------|---------|
| Overall      | *Davallia denticulata* | 21.85  | 13.89  | 17.87   |
|              | *Microsorum scolopendria* | 18.29  | 13.43  | 15.86   |
|              | *Davallia solida*     | 6.35   | 8.33   | 7.34    |
| Kg. Logah    | *Davallia denticulata* | 37.35  | 13.89  | 25.62   |
|              | *Microsorum scolopendria* | 17.88  | 13.89  | 15.88   |
|              | *Vittaria ensiformis* | 18.04  | 12.05  | 15.27   |
| Kg. Sri Rahmat | *Microsorum scolopendria* | 19.76  | 12.50  | 16.13   |
|              | *Nephrolepis cordifolia* | 17.05  | 12.50  | 14.78   |
|              | *Stenochlaena palustris* | 16.76  | 12.50  | 14.63   |
| Felda Medoi  | *Nephrolepis biserrata* | 19.90  | 15.63  | 17.76   |
|              | *Davallia denticulata* | 14.86  | 15.63  | 15.24   |
|              | *Microsorum scolopendria* | 15.85  | 14.06  | 14.96   |

From Table 8, the highest IVi value recorded was *D. denticulata* (17.87%) indicating that this species is dominant among all pteridophytes species recorded, followed by *M. scolopendria* (15.86%)
and *D. solida* (7.34%). At Kg. Logah plantation, pteridophytes species were dominated by *D. denticulata* (25.62%) followed by *M. scolopendria* (15.88%) and *D. solida* (15.27%). In contrast, *M. scolopendria* (16.13%) was the dominant species followed by *N. cordifolia* (15.88%) and *S. palustris* (14.63%) at Kg. Sri Rahmat. However, at Felda Medoi *N. biserrata* (17.76%) was the dominant species followed by *D. denticulate* (15.24%) and *M. scolopendria* (14.96%).

3.6. Potential factors affecting pteridophytes species in oil palm plantations.

In this study, the differences in the species compositions among the sites could possibly due to several factors. The three oil palm plantations had different ages, environmental conditions, management history and practices. Oil palm trunks usually grow up to 15 m in 20 years, expanding every 2 leaves per month and were cut when they exceeded for human harvesting oil nuts [39]. Above 15 m of the trunks, the habitat of the ferns diminishes within 20 years due to the absence of leaf base and: Only *V. ensiformis* scarcely hold on the smooth trunks, therefore at Kg. Logah this species was the second highest. Invading speed of *N. biserrata* and *D. denticulate* seems to be fast because both ferns occurring within 1 m height oil palm trunk (2-3 years). This can be seen at Felda Medoi where the shortest oil palm trees were often dominated by these two species. On tall oil palm trunks high frequency of *N. biserrata* was found only upper part of the trunk, thus at Kg. Logah there was no *N. biserrata* recorded due to this study scope only from the ground to 1.5m height. Therefore, *N. biserrata* dominates on the upper part of trunk, while *V. ensiformis* on the bottom of trunk. On the contrary, *Asplenium nidus* is known to be late ferns invading species on trunks of natural forest trees and oil palm in plantation as seen only at Kg. Logah. *A. nidus* occurs in the range of 1-6 m heights above ground on rather tall oil palms more than 4 m. In a previous study of pteridophytic plant association found in the leaf pockets of oil palm trunks in plantations in Peninsular Malaysia, there was a constant association of fern taxa, which include *Nephrolepis auriculata*, *Goniophlebium percussum* and *D. denticulata* [40].

For a particular management practice, it can be seen from Table 4 that Kg. Sri Rahmat had the highest diversity of pteridophytes species due to the lowest management practice. Higher numbers of species were found in the less intensively managed smallholder oil palm systems [41]. Whereas Kg. Logah had the moderate diversity of pteridophytes due to the moderate management practice, followed by Felda Medoi had the lowest diversity due to well management practice. Generally, FELDA also provided credits, inputs, including oil palm seeds, fertilizers, pesticides and the marketability of the crops. Thus, Felda Medoi considered as well- managed plantation.

Next, another factor was elevation. The mostly terrestrial pteridophytes were commonly found at Kg. Sri Rahmat due to the lowest elevation, followed by Kg. Logah which has moderate elevation. While, Felda Medoi with the highest elevation had only two species of terrestrial pteridophytes compared to other plantation. This is because, kg Sri Rahmat has high humidity, low elevation and low light intensity due to short oil palm trees within 1 time pruning once in a year compare to other plantation. Therefore, pteridophyte species can grow optimally on the Kg. Sri Rahmat. According to [42], moist soil has more pteridophyte species. In addition, the fern's coverage was greatest in a low-light under-story environment, where it has been shown to establish and eventually dominate [43].

4. Conclusion

This study showed the potential of monoculture oil palm plantations as ecosystem support for pteridophytes species. Three locations of study area had varying species diversity that represent 32 different species of pteridophytes from 13 families. The composition, diversity and richness of pteridophytes species recorded were relatively moderate in the monoculture oil palm plantations. Older plantations (i.e. Kg. Sri Rahmat & Kg. Logah) hold higher diversity and richness of pteridophytes species but the species evenness varied between the plantations. In addition, the Sørensen similarity index showed relatively low similarities between species among three different location. This indicated a significant influence of plantation age, management histories on the composition and diversity of pteridophytes species between the oil palm plantations.
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References
[1] Fitzherbert E B, Struiebig M J, Morel A, Danielsen F, Brühl C A, Donald P F and Phalan B 2008 How will oil palm expansion affect biodiversity? Trends Ecol. Evol. 23(10) 538-45
[2] Corley R H V and Tinker P B 2003 The oil palm (Oxford: Blackwell Science)
[3] Gaveau D L, Sheil D, Husnayaen, Salim M A, Arjasakusuma S, Ancrenaz M, Pacheco P and Meijaard E 2016 Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. Sci. Rep. 6 32017
[4] Sodhi N S, Koh L P, Brook B W and Ng P K L 2004 Southeast Asian biodiversity: an impending threat. Trends Ecol. Evol. 19 654–60
[5] Wilcove D S, Giam X, Edwards D P, Fisher B and Koh L P 2013 Navjot's nightmare revisited: logging, agriculture, and biodiversity in Southeast Asia. Trends Ecol. Evol. 28 531–40
[6] Wan Mohd Jaafar W S, Said N F S, Abdul Maulud K N, Uning R, Latif M T and Muhmad Kamarulzaman A M 2020 Carbon emissions from oil palm induced forest and peatland conversion in Sabah and Sarawak, Malaysia Forests 11(12) 1285
[7] Buckley R 1999 A Review of the Fossil Cycads. The Palm and Cycad Society of Florida
[8] Goswami H K, Sen K and Mukhopadhyay R 2016 Pteridophytes: evolutionary boon as medicinal plants. Plant Genet. Resour. 14 (4) 328-55
[9] Mehltreter K, Walker L R and Sharpe J M 2010 Fern ecology (Cambridge: Cambridge University Press)
[10] World Conservation Monitoring Centre 1992 Global biodiversity: status of the Earth’s living resources (London: Chapman & Hall)
[11] Hoshizaki B J and Moran R C 2001 Fern’s Grower Manual (Rev. ed.) (Portland, USA: Timber Press)
[12] The Plant List 2013 A working list for all plant species (n.d.) version 1.1. Downloaded from http://www.theplantlist.org/1.1/browse/P on 12-03-2019
[13] Roos M 1996 Mapping the world’s pteridophyte diversity: systematic and floras In J. M. Camus, M. Gibby, & R. J. Johns (Eds.) Pteridology in perspective (Kew: Royal Botanic Gardens, Kew) pp 29– 42
[14] Parris B S 1997 Towards a pteridophyte flora Malaysia; a provisional checklist of taxa Malay. Nat. J. 50 235-80
[15] Um Kalsom Y 2010 Ferns of Malaysian rain forest: a journey through the fern world (Serdang: lowland rainforest of Khao Nan nationalpark, Nakhon Si Thammarat province, Thailand. Universiti Putra Malaysia Press)
[16] Boonkerd T, Chantanaosirapint S and Khwaiphan W 2008 Pteridophyte diversity in the tropical Trop. Nat. Hist. 8(2) 83-97
[17] Luke S H, Purunomo D, Advento A D, Arayawan A G K, Naim M, Pikstein R N, Ps S, Rambe T S, Soepapto, Caliman J P, Snaddon J K, Foster W A and Turner E C 2019 effects of understory vegetation management on plant communities in oil palm plantations in Sumatra, Indonesia Front. For. Glob. Change 2 33
[18] Prescott G W, Edwards D P and Foster W A 2015. Retaining biodiversity in intensive farmland: epiphyte removal in oil palm plantations does not affect yield Ecol. Evol. 5(10) 1944-54
[19] Parris B S, Kiew R, Chung R C K, Saw L G and Soepadmo E 2010 Flora of Peninsular Malaysia, Series I: Ferns and Lycophytes, Vol. 1 (Kuala Lumpur: Forest Research Institute Malaysia (FRIM)) pp 429
[21] Piggott A G and Piggott C J 1988 *Ferns of Malaysia in colour* (Kuala Lumpur, Malaysia: Tropical Press) pp 458

[22] Spellerberg I F and Fedor P J 2003 A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the ‘Shannon–Wiener’ Index. *Glob. Ecol. Biogeogr.* **12**(3) 177-79

[23] Molinari J 1989 A calibrated index for the measurement of evenness *Oikos* **56**(3) 319-326.

[24] Sørensen T A 1948 A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons *Biol. Skar* **5** 1-34

[25] Magurran A E 2004 *Measuring biological diversity* (Malden, MA: Blackwell)

[26] Cottam G and Curtis J T 1956 The use of distance measures in phytosociological sampling *Ecology* **37**(3) 451-60

[27] Barthlott W, Schmit-Neuerburg V, Nieder J and Engwald S 2001 Diversity and abundance of vascular epiphytes: a comparison of secondary vegetation and primary montane rain forest in the Venezuelan Andes *Plant Ecol.* **152**(2) 145-56

[28] Adnan N S, Karim M F A, Mazri N H, Fikri N A, Saharizan N, Ali N B M and Zakaria R 2020, August Plants Diversity in Small Rubber Plantations at Segamat, Johor In *IOP Conference Series: Earth and Environmental Science* (Vol. 549, No. 1, p. 012033)

[29] Sharpe, Joanne and Mehltreter, Klaus and Walker L R 2010 Ecological importance of ferns *Fern Ecol.* 1-21

[30] Elliott K J and Swank W T 1994 Changes in tree species diversity after successive clearcuts in the Southern Appalachians *J. Veg. Sci.* **11**(1) 11-18

[31] Colwell R K and Elensohn J E 2014 Estimates turns 20: statistical estimation of species richness and shared species from samples, with non-parametric extrapolation *Ecography* **37**(6) 609–13

[32] King J R and Porter S D 2005 Evaluation of sampling methods and species richness estimators for ants in upland ecosystems in Florida *Environ. Entomol.* **34**(6) 1566–78

[33] Imaniar R, Pujaistuti P and Murdiyah S 2017 Identifikasi keanekaragaman tumbuhan paku di kawasan air terjun kapas biru kecamatan Pronojiwo Kabupaten Lumajang serta pemanfaatannya sebagai booklet *Edu-Bio* **6**(3) 337-45

[34] Dudani S N, Mahesh M K, Subash C M D and Ramachandra T V 2014 Pteridophyte diversity in wet evergreen forests of Sakleshpur in Central Western Ghats *Ind J PltSci* **3**(1) 28-39

[35] Kent M 2012 *Vegetation Description and Data Analysis* (Hoboken, NJ: Wiley-Blackwell)

[36] Kraehmer H 2016 *Atlas of Weed Mapping* (Hoboken, NJ: John Wiley & Sons)

[37] Ali A, Badshah L, and Hussain F 2018 vegetation structure and threats to montane temperate ecosystems in Hindukush Range, Swat, Pakistan *Appl. Ecol. Environ. Res.* **16**(4) 4789–4811

[38] Badshah L, Hussain F and Sher Z 2016 Floristic inventory, ecological characteristics and biological spectrum of plants of Parachinar, Kurram agency, Pakistan *Pak. J. Bot.* **48**(4) 1547-58

[39] Abdullah N 2013 *The Oil Palm Wastes in Malaysia* IntechOpen

[40] Yusuf F B, Tan B C and Turner I M 2003 Species richness of pteridophytes in natural versus man-made lowland forests in Malaysia and Singapore *In Pteridology in the New Millennium* (Dordrecht: Springer) pp 283-298

[41] Rembold K, Mangopo H, Tjitrosoedirdjo S S and Kreft H 2017 Plant diversity, forest dependency, and alien plant invasions in tropical agricultural landscapes *Biol. Conserv.* **213** 234–42

[42] Hamel T, Boulematsafes A, Slimani A, El Mouaz Madoui B and Drid M D 2017 Diversity and ecology of Pteridophytes in the Skikda region (North East Algeria) *Int. J. Biol. Sci.* **6**(3) 42-47

[43] Pemberton R W and Ferriter A P 1998 Old World climbing fern (*Lygodium microphyllum*), a dangerous invasive weed in Florida *Am. Fern J.* 165-75