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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 (E_H=0.73) whereas at Kg. Logah and Felda Medoi, the species evenness was less significant different (E_H=0.66 and E_H=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

million 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 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 Goniophlebium 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.

Figure 1. Study areas and sampling locations.

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 & 1x neutral	Organic & Chemical
Treatment (Pruning)	2x in a year	1x in a year	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 45ºC to 50ºC) 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),

$$H - -\sum_{i=1}^{S}(p_i \ln p_i) \quad (1)$$

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),

$$E_H = \frac{H}{Hmax} = \frac{H'}{\ln S} \quad (2)$$

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),

$$\text{Sorensen's coefficient (Cs)} = \frac{2a}{2a+b+c} \quad (3)$$

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,

$$d = \frac{S-1}{\ln N} \quad (4)$$

Where;
S = the number of species
N = the total number of individuals in the sample

2.4.3. Abundance parameter.

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

Where,
ni = 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),

$$\text{Frequency} = \frac{\text{total of quadrant in which species occur}}{\text{total number of quadrant}} \times 100 = \frac{ji}{k} \quad (6)$$

Where,
ji = number of quadrant in which species occur
k = total number of quadrant studied

2.4.4. Importance value index (IVi). 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. $$IVi = \frac{\text{relative density} + \text{relative frequency}}{2} \quad (7)$$

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 can take advantage of anthropogenic disturbance, and 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	*Stenochlaena palustris*	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
Nephrolepidaceae	*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
	Phymatopteris	*Phymatopteris laciniata*	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')	H_{max}	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. Sørensen 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 (IV*i*) of dominant species recorded at different aged of all three oil palm plantations at Segamat, Johor.

Plantation	Species	Rd (%)	Rf (%)	IV*i* (%)
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 IV_i 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. bisserrata* and *D. denticulata* 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. bisserrata* was found only upper part of the trunk, thus at Kg. Logah there was no *N. bisserrata* recorded due to this study scope only from the ground to 1.5m height. Therefore*, N. bisserrata* 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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