A PRELIMINARY STUDY OF FERN DIVERSITY IN UiTM PAHANG FOREST RESERVE, PAHANG

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Abstract

The diversity of ferns (Pteridophyta) in UiTM Pahang Forest Reserve has not been widely reported, and thus the aim of this preliminary study is to assess the fern diversity and richness at UiTM Pahang Forest Reserve, Pahang. A total of 10 plots, sized of 10 × 10 m each, with a minimum distance of 20 m between each plot, were established at different locations using quadrat sampling method. A total of 330 individual ferns from 11 different species across 8 families were found in all sampled plots. *Dicranopteris linearis*, *Nephrolepis biserrata* and *Thelypteris opulenta* were observed to be the most abundant species, while *Asplenium nidus* were the least common species. The values of Shannon-Weiner biodiversity index (H') and species richness index ($I_{Margalef}$) in UiTM Pahang Forest Reserve were 2.22 and 1.73, respectively. The diversity index value indicated that the fern diversity in UiTM Pahang Forest Reserve is low, while the evenness index (E=0.84) also indicated that the number of individuals in each fern species is unevenly distributed. However, the low diversity of ferns in UiTM Pahang Forest Reserve could be regarded due to the small area being assessed in this study and therefore, an extensive survey should be employed to fully capture the diversity index value of this forest area.

Keyword: diversity, ferns, richness, UiTM Pahang Forest Reserve.

Introduction

Pteridophyte, the first vascular plants group (ferns), is comprised of about 13,742 species that are geographically distributed across the globe (Melnikov et al., 2021). Malaysia is known for its rich variety of fern species, with approximately 1165 distinct species documented in its tropical rainforests and among these, 750 species are found in Sabah, 615 in Sarawak, and 647 in Peninsular Malaysia (Akomolafe & Rahmad, 2019). The distribution and diversity of fern species in Malaysia, particularly in the tropical rainforests, have been the focus of several studies. Moreover, such interest has been shown in the fern species diversity and distribution across Malaysia, where researchers indicate richness in Pteridophytes caused by ever-wet climate (Nazihah et al., 2018). Fern population and dispersal fluctuate extensively because the spores can be easily transferred by wind or any other medium and may exist in conditions that are less than ideal. Habitats of ferns include terrestrial, epiphytic, aquatic, and high alpine forest areas. Ferns, according to Anderson (2021), have a geological history spanning back millions of years and can be found in various habitats, including swamps, coastal regions, open grasslands, mountainous terrains, arid plains, and deserts.

Ferns are important features of plant biodiversity through diversity, distribution, and richness. However, they are relatively lesser studied in view of the change in environment and deforestation, especially in Malaysia. Fern survival is at risk as a result of forest destruction, which has an impact on their conservation status, particularly for species that prefer shade and are more vulnerable to habitat changes (Kreshchenok & Lesik, 2022). This is further emphasized by the fact that ferns usually have limited habitats and intrinsic sensitivity to alterations in the environment (Yang Long et al., 2021). This study was therefore quite imperative since the documentation of Pteridophytes diversities in Malaysia and specifically in UiTM Pahang Forest Reserve is regarded as very deficient compared to angiosperms and other higher plants. In Pahang, only several studies on fern diversity have been documented with 32 species of terrestrial Pteridophytes were recorded in Genting Highlands (Salifah et al., 2009) and 14 species were recorded in 5 districts in Kuantan (Nazihah et al., 2018). The present study aimed to determine the diversity and richness of fern species found in UiTM Pahang Forest Reserve. This study is expected to provide a vital information about the taxonomic diversity of Pteridophytes in UiTM Pahang and thus serves as a baseline information for conversation and sustainable management of forest ecosystems in the campus.

Materials and Methods

Study Area

The study was carried out from March until June 2024 at UiTM Pahang Forest Reserve which is located in UiTM Cawangan Pahang, Jengka Campus (3° 45' 23.652", 102° 33' 39.78") (**Figure 1**). The sampling period was conducted during the dry season, which receives an average monthly rainfall of 110–160 mm and a mean monthly temperature ranging between 25°C to 36°C. Characteristics of tropical rainforest in Malaysia include having regular rainfall in between 2000 to 2500 mm per year, and temperature of 29°C to 38°C (Hazir et al., 2020). UiTM Pahang Forest Reserve that consists of 250 acres forest reserve is a part of Jengka Forest Reserve and located in Bandar Pusat Jengka, Pahang. The forest reserve's donation by the Pahang State government in 1985 was intended to be used for research and educational activities (Muzamil Mustaffa et al., 2010). Kem Sri Gading UiTM Cawangan Pahang was developed in the UiTM Pahang Forest Reserve to cater the needs of these activities.

Figure 1 Google earth image showing the sampling area (yellow circle) in UiTM Pahang Forest Reserve (coordinate: 3° 45' 45.792", 102° 34' 19.776").

Sampling Method and Analysis

A simple preferential quadrat sampling method was adopted for the study. The diversity and individual numbers of ferns found along the trail in UiTM Pahang Forest Reserve up to the Kem Sri Gading, UiTM Cawangan Pahang, which is the centre point of UiTM Pahang Forest Reserve, were recorded. A total of 10 plots, with a size of 10 × 10 m each, were established preferentially by placing them where a fern was found. The sampling plot in each site was separated by a minimum distance of 20 m. Early identification of the ferns species during the sampling was done using iNaturalist application and later, the identity of each fern was confirmed using the International Plant Names Index (IPNI) and a flora (Piggott, 1988; Large & Braggins, 2009). The ferns diversity indices such as (Shannon index = H'), species richness (Margalef index = $I_{Margalef}$) and Evenness Index (E) were estimated using PAST 4.0 software.

Results and Discussion

A total of 330 individual ferns were found within the study plots, comprising of 11 species belonging to 11 genera and 8 families (**Table 1**). The families Polypodiaceae and Pteridaceae were represented by three and two species, respectively, while the remaining families were represented by only one species each. *D. linearis* and *N. biserrata* were the species with the highest number of individuals fern represented by 58 individuals, followed by *T. opulenta* with 50 individuals. The lowest number of individual ferns was *A. nidus*, with only 6 individuals recorded within all plots. *N. biserrata* and *D. linearis* were also found to be the most frequent species occurring in all plots with 80% and 70% occurrences, respectively, followed by *Taenitis blechnoides* and *Blechnopsis orientalis* with 60% occurrence. Meanwhile, *Adiantum diaphanum* was the species with the least occurrence in all plots with only 20% occurrence (**Table 2).** *A. nidus,* on the other hand, was recorded to be found in 3 plots (30% occurrence), even though the species was represented with the lowest individual's number of ferns. Although there were variations in the individuals number of fern species at each plot, the highest number of individuals were found in Plot 5, Plot 7 and Plot 1 with 71, 64 and 48 individuals, respectively (**Table 2**). The high numbers of individual ferns in Plot 5 and Plot 1 were mostly dominated by the monospecific populations of *D. linearis, N. biserrata* and *T. opulenta,* while in Plot 7, due to the high number of fern species occurred within the plot, was represented by various number of individuals. However, it is noteworthy to notice that none of *D. linearis* was recorded in this plot.

Table 1 Fern species recorded in UiTM Pahang Forest Reserve, Pahang

Species	Genus	Family	Common name	Total individuals
Adiantum diaphanum	*Adiantum*	Pteridaceae	Filmy Maidenhair Fern	12
Asplenium nidus	*Asplenium*	Aspleniaceae	Bird's Nest Fern	6
Blechnopsis orientalis	*Blechnopsis*	Blechnaceae	Centipede Fern, Paku Lipan	26
Dicranopteris linearis	*Dicranopteris*	Gleicheniaceae	False Staghorn Fern, Paku Resam	58

Drynaria quercifolia	*Drynaria*	Polypodiaceae	Oakleaf Fern, Daun Kelapa Tupai	12
Lygodium longifolium	*Lygodium*	Lygodiaceae	None	32
Microsorum scolopendria	*Microsorum*	Polypodiaceae	Wart Fern, Maile-scented Fern	28
Nephrolepis biserrata	*Nephrolepis*	Nephrolepidaceae	Sword Fern, Paku Larut	58
Pyrrosia piloselloides	*Pyrrosia*	Polypodiaceae	Felt Fern, Dragon's Scale Fern	18
Taenitis blechnoides	*Taenitis*	Pteridaceae	Ribbon Fern	30
Thelypteris opulenta	*Thelypteris*	Thelypteridaceae	Jewelled Maiden Fern	50

The higher number of individuals of *D. linearis* observed in this forest indicated the fern has the tendency to be an aggressive species distributed within the forest area. *Dicranopteris* species have often been considered as obstacles that interfere with forest succession because they form thickets which compete with trees for soil water, soil nutrients, and solar radiation (Long Yang et al., 2021). This assessment has been applied to *D. dichotoma* in South China (Huan et al., 1984; Pang et al., 2018) and *D. linearis* in Sri Lanka (Cohen et al., 1995) and Hawaii (Russell, 1998). On the other hands, *N. biserrata* is a fern species that grows wild and has high adaptability such as able to grow well in poor soil conditions and in shaded condition (Satriawan et al., 2021). *Asplenium* species have been noted for their abundance in tropical forest throughout the world (Ellwood & Foster, 2004), and *A. nidus* occurrence usually creates a special microclimatic condition in disturbed forests (Cummings et al., 2006). Contrariwise, *A. nidus* was recorded to be the least common species to be found in the study area. which prominently indicated the study site is a less disturbed forest area. Polypodiaceae, the family represented with the highest number of species in the study area, was also reported as the most diversified family in the tropical rain forest (Zapfack et al., 1996).

Table 2 Individual number of ferns species in each plot

Species	**Plots Quadrat**									
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Adiantum diaphanum	0	0	0	8	0	0	4	0	0	0
Asplenium nidus	0	0	0	3	2	0	1	0	0	0
Blechnopsis orientalis	5	0	5	4	5	0	4	0	3	0
Dicranopteris linearis	8	2	9	0	18	5	0	0	8	8
Drynaria quercifolia	0	0	0	0	0	0	7	5	0	0
Lygodium longifolium	0	0	0	15	0	0	10	7	0	0
Microsorum scolopendria	10	0	5	0	8	0	5	0	0	0
N. biserrata	10	4	5	0	7	5	9	0	15	3
Pyrrosia piloselloides	5	0	7	0	3	0	3	0	0	0
Taenitis blechnoides	4	0	4	7	5	0	7	3	0	0
Thelypteris opulenta	6	0	7	0	23	0	14	0	0	0

The diversity indices analysis revealed that the Shannon index (H') values recorded for fern species in UiTM Pahang Forest Reserve was 2.22, while the species richness value index ($I_{Margalef}$) and Evenness index (E) were 1.73 and 0.84, respectively (**Table 3**). The diversity indices analysis by plots showed that Plot 7 has the highest value of Shannon index (H') index, followed by Plot 3 and Plot 1, with a given value of 2.13, 1.91 and 1.89, respectively (**Table 4**). The lowest diversity index (H') was given by plot 10 with a value of 0.59. The species richness analysis ($I_{Margalef}$) also revealed that Plot 7 has the highest value of 2.16, followed by Plot 5 and Plot 3 with 1.64 and 1.61, respectively, while Plot 10 also was recorded with the lowest value for this index (0.42). The Evenness Index (E) value was not distinctly different between plots, with a value ranging between 0.75–1.00. The diversity observed in UiTM Pahang Forest Reserve highlights the area's suitability for fern growth, likely due to favourable environmental conditions such as high humidity, shaded areas, and nutrient-rich soils. The key climatic factors that have been identified as drivers of plants species distribution across large spatial scales include the precipitation seasonality, precipitation during the driest month, minimum temperature of the coldest month, annual precipitation, mean annual temperature, and temperature seasonality (Kooyman et al., 2012). Increase in light and temperature showed a negative effect on the fern species richness and abundance in the *Abies religiosa* forest of the Magdalena River Basin (Oseguera-Olalde et al., 2022). Fern community is highly sensitive to nutrient availability, as reported by Viana et al. (2021), who observed a greater abundance of terrestrial ferns in sites with a greater light interception by the canopy, which in turn was related to richer phosphorus soils in Panama.

Table 3 Ferns diversity indices of the study plots

Diversity Indices	Indices Values
No. of species	11
No. of individuals	330
Simpson's index	0.88
Shannon index	2.22
Species Evenness	0.84
Margalef Index	1.73

Table 4 Ferns diversity indices by each study plots

Diversity Indices	Plots Quadrat									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
No. of species	7	2	7	5	8	2	10	3	3	2
No. of individuals	48	6	42	37	71	10	64	15	26	11
Simpson's index	0.84	0.44	0.85	0.73	0.80	0.50	0.87	0.63	0.56	0.40
Shannon index	1.89	0.64	1.91	1.46	1.80	0.70	2.13	1.04	0.93	0.59
Species Evenness	0.95	0.94	0.97	0.86	0.75	1.00	0.85	0.95	0.84	0.90
Margalef Index	1.55	0.56	1.61	1.11	1.64	0.43	2.16	0.74	0.61	0.42

The higher proportion of the terrestrial ferns in UiTM Pahang Forest Reserve could indicates that the forest is less disturbed, despite being a regular place for student activities in regard to educational and recreational purposes. The higher proportion of the terrestrial ferns in Bukit Larut, Taiping, could indicates that the forest is less disturbed, despite being a recreational hill forest, because terrestrial ferns are known to be more common in less disturbed forests (Akomolafe et al., 2021). The same trend was also observed in Ayer Hitam Forest Reserve (AHFR), the largest peat swamp forest in Johor, where a total of 71 fern species were found in the forest (Akomolafe et al., 2022). The less-disturbed forest is richer in ferns than the

more-disturbed forest. Corbett et al. (2002) observed lesser number of fern species in the highly disturbed forest than the less disturbed one in some parts of Oklahoma, USA. A similar trend was also observed in Thailand, where highly disturbed sites had the lowest number of species, but the highest number of individual ferns were observed in each plot than the less-disturbed ones (Sathapattayanon & Boonkerd, 2006). Even though the study site showed a considerable number of fern species, but it is lower than the fern species recorded in the less disturbed forest area in the main campus of USM (Rahmad & Akomolafe, 2018). The lower populations of fern species in the study area are probably caused by microclimatic changes, in addition to the intensity of human activities since such disturbances can cause habitat deterioration. Terrestrial ferns are more susceptible to human threats than epiphytic and aquatic ferns as they can be easily removed alongside with other herbaceous plants (Rahmad & Akomolafe, 2018).

The Shannon diversity index is very frequently utilized to assess and identify the diversity of plant species. The Shannon diversity index has been widely used to measure diversity at different levels, from genes and populations to whole species and ecosystems (Konopiński, 2020). According to the Shannon diversity index scale (Shanon, 1948), UiTM Pahang Forest Reserve was observed to have a low level of fern diversity. However, according to Barbour et al. (1999), a community with Shannon index greater than 2 is regarded as more diverse. Meanwhile, the low evenness value is due to the existence of species that have a high number of individuals or dominant species, and the number of individuals in each species is uneven. The low species evenness index can be related to the low number of ferns (Kaulika & Nurza, 2021). Ecosystems with higher species diversity tend to be more stable and have higher level of productivity due to the dynamic nature of the species driving them (Rahmad and Akomolafe, 2018). Even though the edaphic factor is not the main focus in this study, it does influence the fern communities to some extent. Natural diversity and composition patterns of ferns depend highly on environmental conditions such as moisture, temperature, and light imposed by altitudinal gradients. High species richness of terrestrial ferns in lowland tropical forests is due to better edaphic conditions (Suis et al. 2021). Plot 10 showed a relatively lower number of species and individual number of ferns, perhaps due to the low relative humidity and higher light intensity in the plot area compared to Plot 7, Plot 5, Plot 3, and Plot 1. This preliminary study did not extensively cover the whole forest reserve area, perhaps there might be a different trend in the diversity and richness of the ferns if the area being assessed was larger.

Conclusion

This preliminary study of fern diversity revealed that 11 species of fern present in UiTM Pahang Forest Reserve are *Adiantum diaphanum, Asplenium nidus, Blechnopsis orientalis, D. linearis, Drynaria quercifolia, Lygodium longifolium, Microsorum scolopendria, N.biserrata, Pyrrosia piloselloides, Taenitis blechnoides* and *Thelypteris opulenta.* The diversity, richness, and evenness of ferns in this area is low and uneven, but the number of individuals found for *D. linearis, N. biserrata* and *T. opulenta* are high. Considering the small areas assessed, there were possibility that many more species could be recorded if the explored area was expanded. Therefore, further detailed studies must be carried out to cover the vast and deeper area of UiTM Pahang Forest Reserve to provide a completer and more comprehensive fern species list.

Ethics Statement

The research does not require research ethics approval.

Authors Contribution

Writing – Original draft preparation, Nurul Izzah Zolkhoiry; Literature Review, Nur Thabitah Shaikh Nasir, Liliwirianis Nawi, and Siti Nurhafiza Mohd Khazaai; Methodology, Nurun Nadhirah Md Isa and Sarah Laila Mohd Jan, Writing – Review and editing, Nor Lailatul Wahidah Musa."

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Conflict of interests

The author(s) confirm that this article content has no conflicts of interest.

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