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Successional Plant Communities and Factors Affecting their Distribution at Sultan Azlan Shah Campus (KSAS), Proton City UPSI

Komuniti Tumbuhan Sesaran dan Faktor-faktor yang Mempengaruhi Sebarannya di Kampus Sultan Azlan Shah (KSAS), Proton City UPSI

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Abstract

This study aimed to identify the distribution of plant species at Sultan Azlan Shah Campus (KSAS), UPSI before the construction of new campus was pursued. Several abiotic factors that might have affected the plant distribution including light intensity, temperature, relative humidity, wind speed and soil characteristics were also studied. The line transect method was used in 5 different selected plots covering the flat deserted land (Plot A, D and E) up to the hills of 140 m altitude (Plot B and C) surrounding the gazetted area for the development. A total of 23 plant species have been identified with three most abundant species, *Imperata cylindrica*, *Eleusine indica* and *Gleichenia linearis*. The highest frequencies of plant species found in the studied plots are *G. linearis* and *E. longofolium* (12.3%), followed by *Lycopodium cernum* (10.5%) and *I. cylindrica* (8.8%). The abiotic factors such as light intensity, temperature and relative humidity were higher than the average annual readings in Malaysia, clearly influenced the distribution of plant species. On the other hand, wind speed reading did not show uniform results at any plot areas but affected the type of successive vegetation at the studied area.

Keywords successional plant communities, distribution, abiotic factors, light intensity, temperature, relative humidity, wind speed

Abstrak

Kajian ini bertujuan untuk mengenal pasti taburan spesis tumbuhan di Kampus Sultan Azlan Shah (KSAS), UPSI sebelum pembinaan kampus baru dimulakan. Beberapa faktor abiotik yang berkemungkinan telah menjejaskan taburan tumbuhan termasuk keamatan cahaya, suhu, kelembapan, kelajuan angin dan ciri-ciri tanah juga telah dikaji. Kaedah garis transek telah digunakan dalam 5 plot terpilih yang meliputi kawasan tanah rata (Plot A, D, dan E) dan kawasan bukit sehingga ketinggian 140 m (Plot B dan C) di sekitar kawasan yang diwartakan untuk pembangunan. Sebanyak 23 spesis tumbuhan yang telah dikenal pasti dengan tiga spesies yang paling banyak iaitu *Imperata cylindrica*, *Eleusine indica* dan *Gleichenia linearis*. Frekuensi tertinggi spesies tumbuhan yang ditemui dalam plot kajian adalah *G. linearis* and *E. longofolium* (12.3%), diikuti oleh *Lycopodium cernum* (10.5%) dan *I. cylindrica* (8.8%). Faktor abiotik seperti keamatan cahaya, suhu dan kelembapan relatif adalah lebih tinggi daripada bacaan tahunan di Malaysia yang jelas mempengaruhi taburan spesies tumbuhan. Sebaliknya, kelajuan angin tidak menunjukkan keputusan seragam di mana-mana kawasan plot tetapi memberi kesan kepada jenis vegetasi peralihan di kawasan kajian.

Kata kunci komuniti tumbuhan sesaran, taburan, faktor abiotik, keamatan cahaya, suhu, kelembapan relatif, kelajuan angin

INTRODUCTION

New campus of Universiti Pendidikan Sultan Idris (UPSI), Sultan Azlan Shah Campus (KSAS) was officially launched in 2012 by Her Royal Highness, the chancellor of UPSI, after more than 10 years of its ground breaking ceremony. Due to economic crisis within the period of time, the construction of new buildings delayed leaving the wide open land to experience the harshness of climate and weather.

This area was once a dense forest with several layers of vegetation, thus creating a shady forest canopy suitable for the occupation of diverse organisms. However, when the government announced the opening of an industrial area Proton City in 1996 the forests and hills had been cleared and cleaned to enable the realization of large projects such as the Proton manufacturing plant (Proton City) and KSAS, UPSI. This contributed to many environmental changes including erosion due to rainfall trend (Hashim et al, 2012), an increase in temperature and loss of habitat for many organisms. Nevertheless, there are flora and fauna communities which still could survive by adapting to new habitat that had become more extreme and significantly dissimilar to the original habitat. After a period of time which usually takes years, decades even centuries, a climax community would eventually established and maintain its stability (Emery et al., 2012)

Communities of fauna and flora living in the deserted areas play a vital role in the process of succession. The community of pioneer species modifies and improves the environment until the area becomes a more suitable habitat for other species to live (Gan and Choong, 2003). By adapting to new environment, evolutionary process is taking place in the anatomy, physiology or behaviour of a population which increases the population's ability to survive in a particular environment (Molles, 2005). The changes in the structure or function that could be inherited from generation to generation improve the relevance of an organism to the environment that is not suitable (Hopkins, 2007; Emery et al., 2012).

Impact of land clearance in a short period of time to organisms determine the role of pioneering plants species in this area, had never been published. Recognizing the importance of understanding the changes in local environment, which soon will be occupied with buildings and new constructions, this study looked at how plants have survived in a disrupted ecosystem in a short period of time, at the same time to understand the mechanism that optimize the environment for survival.

MATERIALS AND METHODS

Study site

The purposely selected area consisted of five plots around KSAS, UPSI that had not been touched after forest clearance for the construction of the campus since 2001 (Figure 1).

The coordinate for this study site is 3°43’36”N 101°31’55”E, which include flat land up to hills with altitude between 80 m and 140 m above sea level. This study had been carried out between Jun and October 2009.

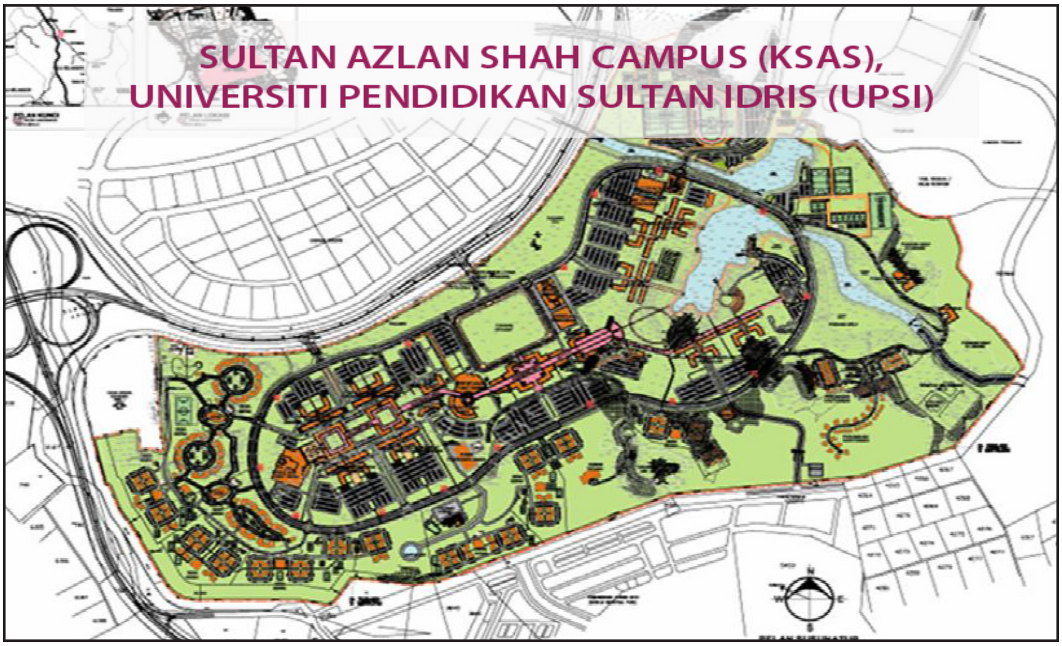

Figure 1 Map of the Sultan Azlan Shah Campus (KSAS), Proton City showing five study plots

Sampling techniques

A systematic sampling was used in this study (Brewer and Cann, 1982). Four 100 m transect lines were marked parallel in the study plots with 10 m distance between them. The same procedures were done at all five plots.

Qualitative measurement

All plants found in the each transect line were identified and counted. The density and frequency of the plant species in each plot were calculated and analyzed using these formulas:

$$Relative\ density = \frac{Number\ of\ invidual\ species}{Total\ individual\ of\ all\ species} \text{ X } 100$$

$$Relative\ frequency = \frac{Frequency\ of\ species}{Total\ frequency\ values\ of\ species} \text{ X } 100$$

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Herbarium

The whole plant or the plants were dipped in ethanol for 30 seconds, dried on tissue papers and pressed under a wooden frame and further dried in oven at 40°C for a week. The dried samples were then mounted on a white herbarium paper and identified by plant systematic experts.

Table 1 Distribution of plant species in the study plots

Plot	Species	Transect				Total	Relative density
		1	2	3	4		
A	*Eleusine indica*	10	39	-	47	96	15.38
	Lycopodium cernuum	-	-	18	5	23	3.69
	Melastoma malabathricum	-	-	2	-	2	0.32
	Ploiarium alternifolium	-	-	1	-	1	0.16
	Gleichenia linearis	-	-	3	-	3	0.48
	Nepenthes gracilis	-	-	-	3	3	0.48
	Eriogonum longifolium	9	-	-	-	9	1.44
B	*Gleichenia linearis*	39	11	-	-	50	8.01
	Nepenthes ampullaria	3	5	-	-	8	1.28
	Eriogonum longifolium	-	-	5	5	10	1.60
	Lycopodium cernuum	-	-	7	-	7	1.12
	Melastoma malabathricum	-	1	-	-	1	0.16
	Imperata cylindrica	-	-	-	1	1	0.16
C	*Lycopodium cernuum*	31	-	7	-	38	6.09
	Melastoma malabathricum	2	1	4	-	7	1.12
	Gleichenia linearis	13	35	29	37	114	18.27
	Imperata cylindrica	14	43	37	39	133	21.31
	Schoutenia accrescens	1	-	-	-	1	0.16
	Melastomata sp.	1	-	-	-	1	0.16
	Zingiber sp.	-	1	-	-	1	0.16
	Clidemia hirta	-	2	1	2	5	0.80
	Porterandia anisophylla	-	1	-	-	1	0.16
	Blechnum indicum	-	-	1	-	1	0.16
	Piper sp.	-	-	-	1	1	0.16
	Ardisia sp.	-	-	-	1	1	0.16
	Fagraea fragrans	-	-	-	1	1	0.16
	Microcos sp.	-	-	-	1	1	0.16
	Eriogonum longifolium	23	19	21	-	43	6.89
	Eriogonum truncatum	-	2	-	-	2	0.32
	Xyris caroliniana	-	1	2	-	3	0.48
D	*Lycopodium cernuum*	15	8	-	-	23	3.69
	Nepenthes gracilis	2	5	-	-	7	1.12
	Imperata cylindrica	3	-	-	-	3	0.48
	Eriogonum longifolium	1	-	-	-	1	0.16
E	*Nepenthes gracilis*	4	-	8	-	12	1.92
	Melastoma sp.	1	-	-	-	1	0.16
	Ageratum conyzoides				8	8	1.28
	Cyperus sp.				1	1	0.16
	Total	172	174	146	152	624	100.00

Table 2 Frequency of the plant species in the study plots

Plant Species	Transect																				F	RF
	Plot A				Plot B				Plot C				Plot D				Plot E					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	%	
Lycopodium cernuum			/	/					/		/		/	/							30	10.5
Melastoma malabathricum			/						/	/	/										20	7.0
Gleichenia linearis			/		/	/			/	/	/	/									35	12.3
Imperata cylindrica									/	/	/	/	/								25	8.8
Schoutenia accrescens									/												5	1.8
Melastoma sp									/								/				10	3.5
Zingiber sp.										/											5	1.8
Clidemia hirta										/	/	/									15	5.3
Porterandia anisophylla										/											5	1.8
Blechnum indicum											/										5	1.8
Piper sp.												/									5	1.8
Ardisia sp.												/									5	1.8
Fagraea fragrans												/									5	1.8
Microcos sp.												/									5	1.8
Eleusine indica	/	/		/																	15	5.3
Ploiarium alternifolium			/																		5	1.8
Nepenthes gracilis				/									/	/							20	7.0
Nephentes ampullaria					/	/															10	3.5
Eriogonum longifolium				/		/	/		/	/	/		/								35	12.3
Eriogonum truncatum										/											5	1.8
Xyris caroliniana										/	/										10	3.5
Ageratum. conyzoides																			/		5	1.8
Cyperus sp																			/		5	1.8

F – Frequency
RF – Relative frequency

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Messurement of abotic factor

Appropriate measurement equipments were used to record the reading of selected abiotic factors. A digital light meter is used to measure light intensity, thermohygrometer to measure ambient temperature and humidity, and anemometer used to measure wind speed. Digital camera used to capture images of plant species found in the transect lines.

RESULTS AND DISCUSSION

Table 1 shows the distribution of plant species found in the five areas of Plot A, B, C, D, and E. The study plots include flat land up to hills with altitude between 80 m and 140 m above sea level. In total, 23 species of plants have been identified in these plots. Plot A has 7 plant species, 6 species in Plot B, 17 species in Plot C, and 4 species each in Plot D and E. A total of 624 individual plants were identified in all studied plots.

Eleusine indica was dominating plot A with relative density of 15.38%, while *Gleichenia linearis* dominated Plot B and C with relative density of 18.01% and 18.27% respectively. Plot C has also dominated by *Imperata cylindrica* with relative density of 21.31% and *Eriogonum longifolium* (6.89%). There were four plant species occupied Plot D and E. *Nepenthes gracilis* was found in both plots.

G. linearis and *E. longofolium* were the most found plant species in the plots studied with relative frequency of 12.3%, followed by *Lycopodium cernum* (10.5%) and *I. cylindrica* (8.8%) (Table 2). These plant species could be found in at four out of five plots studied. Most other plant species have low relative frequency and could only be found in one plot.

Figure 2A shows means of light intensity in the five study plots. It clearly shows the maximum reading occurred during midday. Highest average light intensity readings were recorded at 12 noon at Plot D of 631.7 ± 71.9 (x100Lux) and lowest at 6 pm at Plot E, which was only 11.0 ± 4.6 (x100Lux).

In contrast, the mean relative humidity reduced gradually as it reached midday and increased again towards evening (Fig. 2B). Lowest reading occurred at Plot C (41.4 ± 5.3%) at 12.00 noon and highest at Plot A at 8.00 am (84.9 ± 2.4%). There is no significant difference between plots at the recorded time. The results in this study were similar with the annual humidity at Tanjung Malim District that is 85.2%, with minimum humidity usually occurs in February and maximum in November (Ibrahim et al., 2012). As this study had been carried out between Jun and October, the relative humidity was no different compared with the annual humidity in this area.

The means of day temperature at the study plots did not show any significant differences between plots with the highest temperature occurred at noon. The average reading at 8 am was 24.7 ± 0.01 °C, increased dramatically at 10 am and reached the maximum temperature of 33.4 ± 1.46 °C at 12.00 pm (Fig. 2C). The average daily temperature in Tanjung Malim District is about 28 - 32 °C (Ibrahim et al., 2012). Malaysia has uniform temperature throughout the year with annual variation is less than 2 °C. April and May are the months in which the average monthly temperature is highest while December and January are the months with the lowest average monthly temperature.

The wind speed between plots did not show significant differences between studied plots as they varied from hour to hour. As most plots were open lands, the strong winds occurred during early in the mornings and late evenings, but sometimes at noon. There was no specific period of time for wind speed. Although the wind speed in Malaysia are generally light and varies, changes in the wind patterns are influenced by the four monsoons, namely the southwest monsoon, northeast monsoon and two shorter inter monsoons. The southwest monsoon usually begins in the later half of May or early June and ends in September

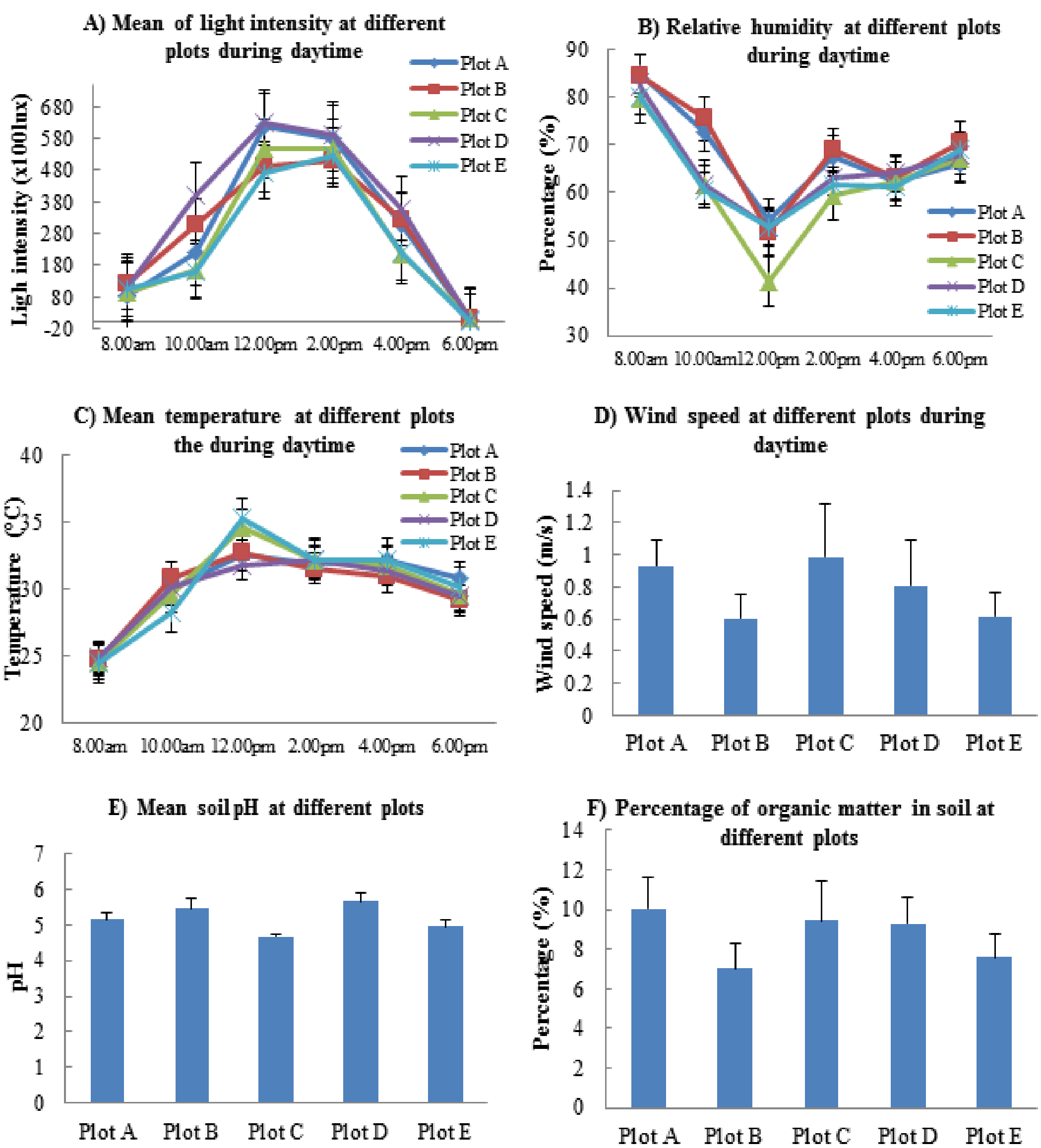

Figure 1 Factors that affecting the distribution of plant species at plot areas in KSAS; A) Light intensity; B) Relative humidity; C) Temperature; D) Wind speed; E) pH; F) Organic matter.

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(Malaysia Meteorological Department, 2009). Therefore, the studied plots should have been exposed to this monsoon wind. Nevertheless, the low average wind speed in this area might be caused by the mountain range surrounding this areas that blocked direct wind.

The soil pH was moderately acidic (pH4-6) and the percentage of organic matter in soil ranged between 7.34% and 10.80%. The soil's water content recorded was between 5.80% and 13.90% (Figure 2E and 2F).

Distribution of plant species at KSAS

The distribution of plant species in an area is influenced by its micro-climates and the successive communities are usually more heterogeneous in disturbed areas than undisturbed areas (Whitfeld et al., 2012). The nature and characteristics of the micro-climate are distinct to its location and usually differ from one to another as there is a lot of differences in terms of space, latitude and altitude, distance from the sea and local properties. In addition, seasons and photoperiods may also affect the chances for plant species to fertilize, disperse, germinate, grow and establish (Hopkin, 2007). Sometimes, differences in micro-climates can occur between the two areas that only a few kilometres away from each other, due to local edaphic factors such as soil, topography and slope aspect (Kubota et al., 2005).

This situation also occurs in the study areas. Although the five plots; A, B, C, D and E are located relatively close to each other; there are different plant distributions between these areas. Plot C has shown the highest distribution and variation of the plant species, with 23 species, ranging from grasses to shrubs such as *Melastoma malabathricum*. The highest relative frequency of plant species in this area are *Imperata cylindrica* and *Gleichenia linearis*. Even though light intensity and relative humidity in Plot C were not significantly different from other plots, but this area has shown a high percentage of soil organic matter which contributed to acidic environment for the plants to absorb the available nutrients from the soil. Thus increase the opportunity of other plant species to occupy this plot.

Early successional plants tend to have high rates of photosynthesis and respiration, high rates of resource uptake, and high light compensation points, whereas late successional plants often have opposite characteristics (Bazzaz 1979). In this study grasses show the most successful species to occupy the deserted land of KSAS. For example *Imperata cylindrica*, a common weed, was found the most abundant in this study, particularly in open areas of Plot C. This species is among the 10 grasses that give a very negative repercussion on the growth of other plants in the world (Miller, 2003). Distribution of this species causes a serious problem in rubber plantation in Asia (Falvey, 1981; Yeoh, 1980). *I. cylindrica* is very aggressive, adaptable to live in areas that lack nutrients and are very difficult to be destroyed because of its strong rhizomes. It has a height of about 0.6 meters and can reach up to 3 meters. Leaf width is about 2 cm and has leaves that are very pointed and sharp at the ends of the leaves (Ngah et al., 2011). Its root can reach up to 1.2 meters deep but only 0.4 meters in the sandy soil type. Because of these features, *I. cylindrica* is usually the pioneering plant species in the newly excavated areas.

Another grass species that highly distributed in Plot A, *Eleusine indica* is easily found almost everywhere, especially in disturbed areas, amid the concrete cracks, pedestrian walks, and in the wild (Chong et al., 2011). These species prefer acidic soil, which suit the growth condition in the studied areas. It also requires moist soil and good drainage to survive. This species flowers from July to August and the seeds reach the level of maturity in August until October. As its pollination is by the wind, living in open area is suitable for the grass to fertilize and disperse. This species is rough, branched at the base, reaching a height of 30 cm to 60 cm and leaf width of 3 mm to 8 mm. It also has a strong fibrous root system which helps retain moisture well during growth throughout the year. These grasses have small biomass, rapid life cycle, faster rate of soil nutrient consumption suit the characteristics of early successional system (Emery et al., 2012).

Nepenthes ampullaria was only found in the hills of Plot B with urn or oval shaped sacs that can reach up to 10 cm high and 7 cm wide. Its peristoma is wide and the small petals are located at the back but do not cover the mouth jar (Clarke, 2001). Sometimes this species climbed other plant species to reach the sunlight. On the other hands *N. gracilis* was found on the ground in the open area of Plot D and E, exposed to more harshness environment. These species usually found in poor acidic soil (Adam et al., 2011). Sharing this difficult environment are *Lycopodium cernuum,* and *Ageratum conyzoides*, common pioneering plant species which always occupy bare soil.

Influence of abiotic and edaphic factors on the distribution of plant species in the KSAS

Malaysia is a tropical country with uniform temperature, high humidity, abundant rainfall and light wind throughout the year. It is rare in Malaysia to have a few days with no sunshine except during the northeast monsoon season. The distribution of plant species is influenced by its climate and weather, rocks and soil, terrain and human activities. Among the elements of weather and climate, the most obvious impact on the distribution of natural vegetation is sunlight, temperature, rainfall and wind (Krebs, 2009).

Influence of intense sunlight radiation can be explained based on the amount of sunlight intensity and length of time the sun shone brightly in an area. Light intensity is a critical limiting factor to plant diversity (Bush, 2000). Based on the findings of our study in the KSAS, the average light intensity was higher than average light intensity of Tanjung Malim. Sunlight is needed by plants to perform photosynthesis. The intensity of sunlight received is also able to determine the growth of vegetation. Light affects the plant growth and an increase in light intensity usually promotes short internodes, thick, and small leaves. Several studies to identify the effects of light intensity showed that low light intensity influenced the chlorophyll content and number of leaves (Wild & Wolf, 1980; Koniger et al., 2008), in turns affects the growth and development of a plant and its distribution in new environment.

High relative frequency of *I. cylindrica*, *Erigonum longifolium*, and *E. indica* shows that grasses are the most abundant plant species to colonize an open land (Table 1). Previous researches have also shown that grasses always dominate excavated areas (Truong et al., 2002; Kubota et al, 2005). The long narrow leaf morphology, short stem and flowers that distributed by wind are among the survival characteristics which allow these plant species to survive the harsh condition (Hopkin, 2007). High temperature and high light intensity provide ample sunlight for better and efficient photosynthesis, and strong wind in this area assists their seed dispersal. On the other hand, at the hilly areas up to 140 m high *G. linearis* dominates the slope areas of Plot B and C. Through observation conducted

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in the study area, there is a relatively small number of *G. linearis* in the open flat land. This indicates that this fern species could grow well in the exposure of high intensity of sunlight and in poor nutrient soils. A study on distribution of *G. Linearis* in Peninsular Malaysia demonstrates the ability of this fern to occupy most land area from lowland up to montane, and occur most at the edge of forests (Rusea et al., 2012) As the altitude increased, other plant species such as *Schoutenia accrescens*, *Zingiber sp*., *Porterandia anisophylla*, *Ardisia sp.*, *Fagraea fragrans* and *Microcos sp.* occupied this area. Most of these species have small green leaves, hard dense branches and stems, and have a height of more than 5 feet. As these plant species are tall enough to expose to the sunlight, there is no necessary for having large broad leaves.

The highest temperature recorded in the studied plots was 35.2 °C which was considered to be high in Malaysia because the average annual temperature is about 27.4°C and highest temperature recorded was 40.1°C was recorded at the meteorological station Chuping, Perak (Malaysian Meteorological Department, 2009). Overall, Figure 1C shows that the average temperature in the studied area is higher than the average annual temperature of Malaysia. Extreme temperature can result in cell inactivity and death of an organism even though there are also organisms that can survive at this temperature. Several adaptations such as having a thick cuticle, a thick leaves, hairs, reduced in stomata number and alternate stomata closure, are among the important characteristics for the plant to survive in extreme temperatures.

Relative humidity varies from morning to evening. However, we could not conclude that the distribution of species in this open lands caused directly by humidity as most of the species seem to adapt to the changes in their environment. It is most likely when the land was cleared none of the species was there. They are newly arrived or introduced by seed dispersal such as wind and animals that passed by this area. Most of them are common pioneering plant species. At the edge of the tropical rainforest canopy, humidity decrease becomes more significant than in the forest canopy (Cadenasso et al., 1997). This is due to perspiration and slow rate of air movement which lower the temperature under canopy (Van der Putten et al., 2000). Moisture profile or water vapour and carbon dioxide are also influenced by wind speed. Uncertain wind speed in this area of study may cause the changes in relative humidity and with no canopy humidity profile does not reach saturation, thus decreases dramatically during the day.

A study on the distribution of plant species in two types of habitat; the open disturbed areas, and the forests, and its relationship with the edaphic factors in Slim Forest Reserve, Perak, has identified more than 120 species of plants including trees, herbs, climbing plant, creepers, and shrubs, covering the forest floor up to the canopy (Saberi and Husni, 2006). The differences in soil variation, altitude and topography between areas could influence the growth and variation of plant species. Nevertheless, the successional communities in barren land such as the KSAS are usually better competitors and colonisers that could optimise the poor conditions to continue their life cycle.

CONCLUSION

This study has shown the plant variation and distribution in excavated areas at Sultan Azlan Shah Campus, UPSI. Five plots of study have been selected covering the flat land up to hilly ares in the altitude of 80-140 m above sea level. Overall, there were 23 species of plants have been identified in these plots in which Plot A has 7 plant species, 6 species in Plot B, 17 species in Plot C, and 4 species in Plot D and E. A total of 624 individual plants were identified in all studied plots. Three most abundant species were *Imperata cylindrica*, *Eleusine indica* and *Gleichenia linearis*. The most frequent plant species found was *G. linearis*, followed by *E. longofolium, Lycopodium cernum* and *I. cylindrical*. Several abiotic factors that might have affected the plant distribution including light intensity, temperature, relative humidity, wind speed and soil characteristics were also studied. The light intensity, temperature and relative humidity were found higher than the average annual readings in Malaysia, whilst wind speed reading did not show uniform results at any plot areas but influenced the distribution of the plant species. The soil pH was slightly acidic and the organic material was found high at the plots with higher plant distribution.

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