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Climbers diversity in Agro Techno Park, Universiti Malaysia Kelantan, Jeli Campus

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Abstract. Species diversity of climbers were inventoried in four nature trails of Agro Techno Park Universiti Malaysia Kelantan (UMK), Jeli campus. The purpose of this study was to determine the diversity, composition and abundances of climbers in Agro Techno Park Universiti Malaysia Kelantan, Jeli Campus. Samples of the climbers were randomly collected from four natural trails for herbarium preparation and preserved using 70% ethanol solution. The preservation was done by putting the samples in zip lock transparent bag that contained of 70% ethanol solution. The samples were oven-dried at 30-40 °C, mounted and labelled before identification. The diversity pattern of the climbers was analyzed by using Shannon Diversity Index, Shannon Evenness Index, Margalef Richness Index, Abundance Parameters and Importance Value Index (IVI). A total of 593 climbers belonging to 35 species were recorded. Family Fabaceae was the most diverse plant from the climbers' family which consisted of 4 genera and 5 species. This was followed by family Menispermaceae, Melastomataceae, Connaraceae, Apocynaceae, Rubiaceae and Vitaceae. The result obtained indicated that alteration of the ecological environment through natural disturbances influenced the abundance and distribution of climbers.

1. Introduction

Climbers are commonly found in temperate and rain forest, and the diversity of climbers can be studied progressively. Malaysia is a blessed country because it was one of the world's oldest richest rainforests. Climbers are ubiquitous which require external support to grow. These climbers available in variety plant families like Dioscoreaceae, Convolvulaceae, Vitaceae, Fabaceae and Cucurbitaceae which could be found in wholly of climbing plants [1]. Previous studies described climbers as any vines that climbs or grows upward from the ground [2]. Climbers germinated on the forest floor require host plant to support them to ascend. Climbing plants would grow and germinate by leaning on, winding around or anchoring to other plants [2].

Climbers showed high diversity in their climbing mechanisms. These included tendrils, aerial roots, twining stems, scramblers, adhesive pads or climbers and clinging stem roots. There are three types of climbing plants that had been distinguished to which were known as lianas or woody-climbing plants, herbaceous climbing plants or vines and climbing shrubs [3].

However, in this case, lianas and vines were recognized as the main groups of climbers. The adaptation of lianas is quite different than the vines. This is because the woody features of lianas allow them to climb the trees until reaching the top strata for sunlight. On the other hand, the vines were



unable to anchor the other plants as higher as lianas do [1]. There were a few studies of lianas diversity that had been done in Malaysia by which a research of the abundance and climbing habitats had been done in dipterocarp forest of Lambir National Park, Sarawak and in a coastal hill forest of Pulau Pangkor, Perak [4, 5]. However, there was no elaborate research on check listing of the herbaceous vines' species specifically in association with habitat disturbance.

The purpose of this study is to determine the diversity, composition and abundances of climbers and prepare a checklist of climbers' diversity in Agro Techno Park Universiti Malaysia Kelantan, Jeli Campus. The study was focused on the diversity of the herbaceous climbers (vines) excluding the lianas since the bark flakiness and the large diameter of lianas limits sampling success

The diversity of climbers and their composition depend on the selection of quadrat plot through general observation. The climbers' diversity in the study area indicates as pioneer species and play important role in forest succession [6].

2. Materials and Methods

2.1. Study Area

This study was conducted at Agro Techno Park Universiti Malaysia Kelantan, Jeli Campus with latitude 5.7503112 and longitudes 101.8435386 (Figure 1). The Agro Techno Park is surrounded by intact fragments of secondary tropical forest dedicated for studies and conservation of natural resources of flora and fauna.



Figure 1. Location of (a) Agro Techno Park UMK and (b) Trails and sampling points.

2.2 Sampling design

Four natural trails (range total distance 25 m - 30 m per trail) were identified at Agro Techno Park, Universiti Malaysia Kelantan. For each trail, four 5 m × 5 m quadrat plots were established on the right- and left-hand side of the trails with a total of 25 m of distance interval. Coordinates and waypoints were marked using GPS device (Garmin, United States). General observation was conducted to note the common vegetation within and surrounding the plot. Climbers were pre-identified based on the characteristics of climbers and the image of the plants was captured by using a camera (Canon, Japan). The morphology and the habitat of the climbers was observed and noted. Among all the trails, only Trail 3 located at hilly slope and adjacent to a stagnant pond.

2.3 Specimen collection, preservation and identification

Herbaceous climbers were pre-identified based on the climbing mechanisms. Climbers intact with leaves, stems and flowers were selected as the best specimen for collection to aid identification process. The stems and flowers were trimmed carefully, tagged and kept separately in zip lock bags which were pre-filled with 70% ethanol solution. All specimens were preserved until the collection of the

specimens was completed. Additional information was also recorded as supporting data. The information noted was the locality, brief description of the climbers and their habitat, name and date. Preserved specimens were pressed by using recycled newspapers and plant press. The samples were dried in oven at 30-40 °C for seven days. Oven-dried specimens were mounted onto A3 sheets and labelled. The herbarium specimens were kept in storage boxes containing silica gels to prevent samples degradation.

The herbarium specimens were identified by using botanical books that includes the Flora of Peninsular Malaysia. Series II: seed plants [7], An Instance Guide to Trees [8] and A Guide to The Common Plants of Ayer Hitam Forest, Selangor, Peninsular Malaysia [9]. The identified specimens were then verified by plant ID expert, Dr Radhiah Binti Zakaria from Faculty of Public Health, Muhammadiyah University of Aceh.

2.4 Data Analysis

2.4.1 Diversity index

Shannon Diversity Index (H') was calculated to account for both abundance and evenness of the common climbers in the plots and based on species richness and species abundance [10]. Species richness is the total of species while, species abundance is the number of individuals per species. The equation of Shannon Diversity Index (H') is shown below:

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

where H' is the Shannon diversity index, P_i is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), and S is the numbers of species encountered.

The evenness of the climbers is measured by applying Shannon's equitability (E_H) as shown below: [19].

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

where E_H is the Shannon Evenness Index, H' is the Shannon Diversity Index, and S is the species diversity.

2.4.2 Richness index

Margalef Diversity index was used to calculate the species richness of the climbers using the following equation [5]:

$$d = \frac{S-1}{\ln N} \quad (3)$$

where S is the number of species and N is the total number of individuals in the sample

2.4.3 Abundance parameter

Abundance parameters were used to calculate the density and frequency of the climbers. Density was used to measure the number of individuals per unit area. Meanwhile, frequency was used to calculate the proportion of sampling units of quadrat. Frequency was usually expressed as a percentage occurrence. The equation to measure the density of climbers is shown below:

$$\text{Density} = \frac{\text{number of individual of species in sampling unit}}{\text{total number of sampling unit studies}} = \frac{ni}{A} \quad (4)$$

where ni is the number of individuals of a species in sampling unit and A is the total number of sampling unit studied. Frequency is proportion of sampling units such as the quadrat or field that contains the species and determined as follows:

$$\text{Frequency} = \frac{\text{total of quadrant in which species occur}}{\text{total number of quadrant}} \times 100 = \frac{ji}{k} \quad (5)$$

where ji is the number of quadrant in which species occur and k is the total number of quadrant studied.

2.4.4 Importance Value Index

Importance Value Index (IVI) is to measure the dominancy of species was in the study area [11]. In this study, the importance value index for climbers was determined by the sum of Relative Density and Relative Frequency for each climber's species using the following equation:

$$IVI = \frac{\text{relative density} + \text{relative frequency}}{2} \quad (6)$$

$$\text{Relative density} = \frac{\text{density of species}}{\text{total density of all species}} \times 100 \quad (7)$$

$$\text{Relative frequency} = \frac{\text{frequency of species}}{\text{total frequency of all species}} \times 100 \quad (8)$$

3.0 Results and Discussion

3.1 Species Composition

A total of 593 climbers which represented 35 species that belong to 30 genera within 20 families were recorded from four nature trails of Agro Techno Park, Universiti Malaysia Kelantan Jeli campus. In Figure 2, Trail 3 recorded the highest number of individuals which was 177, followed by Trail 2 (156 individuals), Trail 1(133 individuals) and Trail 4(127 species). Trail 1 recorded only 29 climbers' species which was the lowest among the trails.

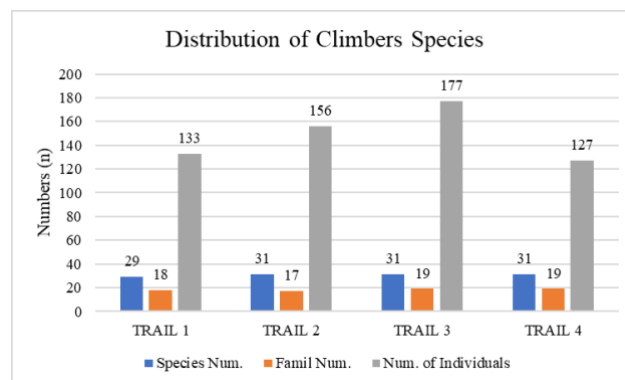


Figure 2. Distribution of climbers from all four nature trails in Agro Techno Park Universiti Malaysia Kelantan (UMK), Jeli campus.

The number of species per family were compared compared (Table 1). Family Fabaceae (5 species, 4 genera) was the most dominant with 89 of individuals recorded followed by family Moraceae (77 individuals), Melastomataceae (47 individuals), Connaraceae (42 individuals), Menispermaceae (37 individuals), Acanthaceae (32 individuals), Apocynaceae and Rubiaceae with 31 individuals, respectively. The remaining climber's family recorded below 30 individuals with only one species per genera except for family Vitaceae (28 individuals) with 2 species and 2 genera.

Table 1. Composition of climbers by family, genera and species in Agro Techno Park Universiti Malaysia Kelantan (UMK), Jeli campus.

No.	Family	No. of Genera	No. of Species	No. of Individuals (n)
1	Fabaceae	4	5	89
2	Moraceae	1	4	77
3	Melastomataceae	2	2	47
4	Connaraceae	2	3	42
5	Menispermaceae	3	3	37
6	Acanthaceae	1	1	32

7	Apocynaceae	2	2	31
8	Rubiaceae	2	2	31
9	Gnetaceae	1	1	30
10	Vitaceae	2	2	28
11	Cucurbitaceae	1	1	27
12	Piperaceae	1	1	22
13	Schizaeaceae	1	1	21
14	Oxalidaceae	1	1	16
15	Araceae	1	1	15
16	Annonaceae	1	1	12
17	Dilleniaceae	1	1	10
18	Dioscoreaceae	1	1	10
19	Blechnaceae	1	1	9
20	Smilacaceae	1	1	7
Total		30	35	593

The predominance of family Fabaceae in this study is consistent with the finding reported by [12] at Lambir National Park, Sarawak. Similarly, *Spatholobus ferugineus*, *Tetracera* spp. and *Gnetum* spp. were also recorded from both studies. In Barro Colorado Island, Panama, 11 climbers' families were recorded which are family Icacinaceae, Fabaceae, Convolvulaceae, Loganiaceae, Palmae, Apocynaceae, Dilleniaceae, Celastraceae, Annonaceae, Gnetaceae and Myrsinaceae. Meanwhile, the species that were found included *Spatholobus ferugineus*, *Strychnos cuspidata*, *Calamus conirostris*, *Tetracera macrophylla*, *Fissistigma rugosa*, *Gnetum neglectum* and *Maesa racementaceae* [4]. These findings are crucial in light of understanding the geographical distribution and commonality of climbers.

3.2 Diversity analysis

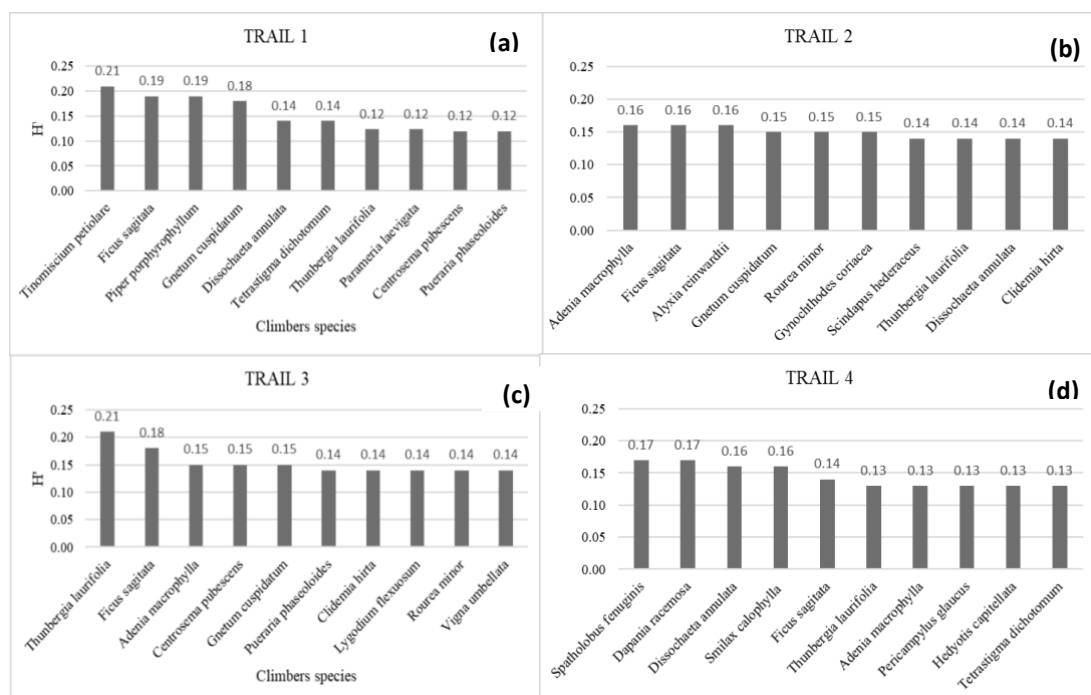
3.2.1 Shannon Index (H'), richness and evenness index

The structural diversity of climbers from all four trails was evaluated using H' which represents the number of species present in a given area or in a given sample, without considering the number of individuals examined in each species [13]. Overall, the H' values from all trails in this study is within the common range, that is between 1.5 - 3.5 and not exceeding the 4.5 unusual mark [17]. Trail 3 recorded the highest climbers' diversity ($H' = 3.28$) followed by Trail 2 ($H' = 3.27$), Trail 1 ($H' = 3.23$) and Trail 4 ($H' = 3.16$), respectively (Table 2). However, Trail 3 recorded the lowest species richness when presented using Margalef's index (d). This indicated that the climbers at Trail 3 were highest in individual's numbers among the trails but not every 35 climber's species were found in all plots within Trail 3. There was only an individual of *Ficus villosa* and *Scindapus hederaceus* found in all the four plots at Trail 3. In contrast, the highest climbers' species richness (d) was represented by Trail 4 ($d = 5.99$) followed by Trail 2 ($d = 5.94$), Trail 1 ($d = 5.93$) and Trail 3 (5.60), respectively (Table 2). Evenness index standardized abundance and range from near 0 when most individuals belong to a few species and to close to 1 when species are nearly equally abundant [14]. By other means, species evenness explained how close climbers' species grow in the plots of each trails. By referring Table 2, Trail 1 and Trail 3 recorded the highest evenness index ($EH = 0.96$), followed by Trail 2 ($EH = 0.95$) and Trail 4 ($EH = 0.92$).

Table 2. Table of diversity index for climbers' diversity, richness and evenness in all four trails of Agro Techno Park Universiti Malaysia Kelantan, Jeli campus.

Diversity Index	Trail 1	Trail 2	Trail 3	Trail 4
Shannon-Wiener Diversity Index (H')	3.23	3.27	3.28	3.16
Margalef's index (d)	5.93	5.94	5.60	5.99
Shannon Evenness Index (EH)	0.96	0.95	0.96	0.92

At species levels, H' for 10 climbers' species with the highest H' values from each trails are shown in Figure 3(a-d). For Trail 1, *Tinomiscium petiolare* recorded the highest diversity ($H' = 0.21$), while *Adenia macrophylla*, *Ficus sagitata* and *Alyxia reinwardtii* were the highest ($H' = 0.16$) at Trail 2. At Trail 3, *Thunbergia laurifolia* recorded the highest diversity ($H' = 0.21$) while *Dapania racemosa* and *Spatholobus fenuginis* were highly diverse ($H' = 0.17$) at Trail 4.

**Figure 3.** Diversity index (H') of ten climbers' species in (a)Trail 1, (b)Trail 2, (c)Trail 3 and (d)Trail 4 of Agro Techno Park Universiti Malaysia Kelantan, Jeli campus.

The variation in species diversity between the four natural trails was most likely influenced by elevation and alteration of the ecological environment through natural disturbance. Based on observation during constructing the plots, area of Trail 3 located at hilly slope that could be formed due to natural landslide. The species richness of climbers was typically higher in the forest groups at lower elevations compared to high elevations [1]. Generally, the vines had grown in disturbed habitat or at the forest edge [23].

The richness fundamentally regulates variation in evenness and diversity statistics [15]. In this case, richness, evenness and diversity indices were strongly correlated. The evenness index (EH) had proved that Trail 1 and Trail 3 showed the highest EH value which was 0.96. This means that climber's species in these trails were evenly spreading and growing in each the sixteen plot samplings. Furthermore, the richness also needed to predict large proportion of their covariance. By considering the resulted value of diversity index of H' and EH, it can be determined that the climbers' species diversity in Agro Techno Park Universiti Malaysia Kelantan (UMK), Jeli campus was diverse with even composition of species.

3.2.2 Abundance Parameters

Abundance parameter was represented by total of density and frequency in the plot of study area. The density is the individual numbers of a species in a unit area and an indication to express numerical of species in the community [16]. Species density especially plant density contributed to sustain the ecosystem and biodiversity since changes in community plant density could result greater positive biodiversity effects [17]. Meanwhile, frequency defined the homogeneity of species distribution in the area [16]. In other term, the homogeneity indicated lack of significant difference between trails or plot sampling.

In this study, frequency was calculated by determining the percentage of total quadrats or plots that contains at least one individual of a climber species. Based on Table 3, the highest density (D) of climbers' species was recorded at Trail 3 with $D = 44.25$ and the lowest one was recorded by Trail 4 with $D = 31.75$. Besides, the highest frequency of climbers' species was recorded by Trail 3 with $F = 21.50$ meanwhile, the lowest F was 19.25 which recorded at Trail 2. Therefore, climbers' species are mostly distributed and frequently found to thrive at Trail 3.

Table 3. Abundance parameter of climbers' species in all four trails of Agro Techno Park Universiti Malaysia Kelantan, Jeli campus.

Trail	Density (D)	Frequency (F)
1	33.25	20.00
2	39.00	19.25
3	44.25	21.50
4	31.75	19.75

Since not all species were found in all the trails, there could be some factors that contributed to this case. This occurrence could be due to difference in distribution pattern of climbers' species between all the trails because of declining ecological environment and human disturbances [1]. By referring the observation at study site, the trails especially Trail 3 are disturbed by natural landslide. Due to the disturbance, ecological environment also got affected by which the temperature in the affected area would make unsuitable for the climbers to grow as steep slope formed at that area. The decline of tree that also act as support plant for the climbers to rely on also caused decline in climbers' diversity as well.

Besides, the availability of light intensity and support also contributed to the climbers' species distribution. Climbers thought that they were demanding light due to their rapid growth in high light. In the early phase of development, climbers need light to germinate, and light supply can constrain their establishment and production [18]. Climbing plants rely on the existence of physical support to enter the canopy and thus protect neighbouring plants from shading [13].

3.2.3 Importance Value Index

The Important Value Index (IVI) is an important parameter for assessing the economic value of the forest as it represents the species with the highest value. IVI is a reasonable measure to determine the overall importance of the species as it takes into account many characteristics of the species in the vegetation [19]. It is also used to prioritize species conservation by requiring a high conservation priority for low IVI species compared to high IVI species. If a species with the lowest IVI value appears to be a valuable species that needed to be conserved, the forest stands will be classified as economically valuable.

The climbers provide valuable food resources, shelter and links between tree canopies that are used as paths for arboreal species [20]. Climbers can also play a role at the habitat level by adding to the carbon budget of tropical forests, accounting for as much as 10% of fresh overground biomass [4]. Top ten dominant climbers' species that were found in Agro Techno Park Universiti Malaysia Kelantan, Jeli campus based on the Important Value Index (IVI) were recorded in Table 4 below. At Trail 1, *Tinomiscium petiolare* ranked the highest IVI value which was 6.64 and *Scindapus hederaceus* ranked the least IVI value which was 4.00. Next, for Trail 2, the highest IVI value was 5.48 which was

represented by *Adenia macrophylla* meanwhile, *Nothocissus spicifera* showed the lowest IVI value by which IVI = 3.56.

Highest IVI value for Trail 3 was 6.56 by which it was *Thunbergia laurifolia*. However, the least IVI value was 3.71 which represented by *Adenia macrophylla*. Moreover, at Trail 4, *Rourea minor* and *Dapania racemosa* shared the highest IVI value which was 5.05 while *Pericampylus glaucus* ranked the lowest with value of 3.87. Among those ten species in all the trails, the highest IVI was 6.64 which was recorded by *Tinomisium petiolare* in Trail 1 and the least one was recorded by *Nothocissus spicifera* with IVI = 3.56 in Trail 2. Overall, *Nothocissus spicifera* from Trail 2 presented as the most valuable species with IVI of 3.56 as compared to other climbers' species.

Table 4. IVI values of ten climbers' species found in Trail 1, Trail 2, Trail 3 and Trail 4.

TRAIL 1		TRAIL 2		TRAIL 3		TRAIL 4	
sp name	IVI	sp name	IVI	sp name	IVI	sp name	IVI
<i>Tinomisium petiolare</i>	6.64	<i>Adenia macrophylla</i>	5.48	<i>Thunbergia laurifolia</i>	6.56	<i>Rourea minor</i>	5.05
<i>Piper porphyrophyllum</i>	5.63	<i>Scindapus hederaceus</i>	4.84	<i>Rourea minor</i>	4.59	<i>Dapania racemosa</i>	5.05
<i>Ficus sagitata</i>	5.01	<i>Alyxia reinwardtii</i>	4.83	<i>Lygodium flexuosum</i>	4.59	<i>Spatholobus fenuginis</i>	4.42
<i>Gnetum cuspidatum</i>	4.63	<i>Centrosema pubescens</i>	4.52	<i>Ficus sagitata</i>	4.55	<i>Agelaea borneensis</i>	4.11
<i>Centrosema pubescens</i>	4.38	<i>Thunbergia laurifolia</i>	4.19	<i>Dioscorea pyrifolia</i>	4.02	<i>Pueraria montana</i>	4.11
<i>Limacia scandens</i>	4.38	<i>Dissochaeta annulata</i>	4.19	<i>Pueraria phaseoloides</i>	4.00	<i>Piper porphyrophyllum</i>	4.11
<i>Lygodium flexuosum</i>	4.38	<i>Ficus villosa</i>	4.19	<i>Vigna umbellata</i>	4.00	<i>Smilax calophylla</i>	4.02
<i>Dissochaeta annulata</i>	4.13	<i>Ficus sagitata</i>	4.18	<i>Clidemia hirta</i>	4.00	<i>Thunbergia laurifolia</i>	3.87
<i>Tetrastigma dichotomum</i>	4.13	<i>Vigna umbellata</i>	3.87	<i>Agelaea borneensis</i>	3.74	<i>Adenia macrophylla</i>	3.87
<i>Scindapus hederaceus</i>	4.00	<i>Nothocissus spicifera</i>	3.56	<i>Adenia macrophylla</i>	3.71	<i>Pericampylus glaucus</i>	3.87

3.3 Checklist of climbers and their climbing mechanism

Climbing mechanism was an adaptation for every climbers' species in order to survive among other plants especially huge trees. Climbers depend on the availability of a physical support to reach the canopy [18]. The previous researchers had classified several ways of climbing mechanism which were (a) hook climber, (b) tendril climber, (c) twiner and (d) root climber [21]. In this study, a checklist of climbers' species and their climbing mechanism is presented in Table 5.

Table 5. Checklist of climbers' diversity in Agro Techno Park Universiti Malaysia Kelantan, Jeli campus.

No.	Species scientific name	Family	Climbing Mechanism
1	<i>Thunbergia laurifolia</i>	Acanthaceae	Tendril
2	<i>Friesodielsia latifolia</i>	Annonaceae	Tendril
3	<i>Parameria laevigata</i>	Apocynaceae	Twiner
4	<i>Alyxia reinwardtii</i>	Apocynaceae	Twiner
5	<i>Scindapus hederaceus</i>	Araceae	Root climber
6	<i>Stenochlaena palutris</i>	Blechnaceae	Root climber
7	<i>Agelaea borneensis</i>	Connaraceae	Twiner
8	<i>Rourea minor</i>	Connaraceae	Twiner
9	<i>Agelaea macrophylla</i>	Connaraceae	Twiner
10	<i>Adenia macrophylla</i>	Cucurbitaceae	Twiner
11	<i>Tetracera scandens</i>	Dilleniaceae	Twiner
12	<i>Dioscorea pyrifolia</i>	Dioscoreaceae	Twiner
13	<i>Centrosema pubescens</i>	Fabaceae	Tendril

No.	Species scientific name	Family	Climbing Mechanism
14	<i>Pueraria phaseoloides</i>	Fabaceae	Tendrill
15	<i>Vigna umbellata</i>	Fabaceae	Twiner
16	<i>Spatholobus fenuginis</i>	Fabaceae	Twiner
17	<i>Pueraria montana</i>	Fabaceae	Tendrill
18	<i>Gnetum cuspidatum</i>	Gnetaceae	Twiner
19	<i>Dissochaeta annulata</i>	Melastomataceae	Tendrill
20	<i>Clidemia hirta</i>	Melastomataceae	Root climber
21	<i>Tinomiscium petiolare</i>	Menispermaceae	Twiner
22	<i>Pericampylus glaucus</i>	Menispermaceae	Twiner
23	<i>Limacia scandens</i>	Menispermaceae	Twiner
24	<i>Ficus sagitata</i>	Moraceae	Root climber
25	<i>Ficus villosa</i>	Moraceae	Root climber
26	<i>Ficus apiocarpa</i>	Moraceae	Root climber
27	<i>Ficus trichocarpa</i>	Moraceae	Root climber
28	<i>Dapania racemosa</i>	Oxalidaceae	Twiner
29	<i>Piper porphyrophyllum</i>	Piperaceae	Root climber
30	<i>Gynochthodes coriacea</i>	Rubiaceae	Twiner
31	<i>Hedyotis capitellata</i>	Rubiaceae	Twiner
32	<i>Lygodium flexuosum</i>	Schizaeaceae	Tendrill
33	<i>Smilax calophylla</i>	Smilacaceae	Hook
34	<i>Tetrastigma dichotomum</i>	Vitaceae	Twiner
35	<i>Nothocissus spicifera</i>	Vitaceae	Twiner

(a) Hook climber

It was a group of climbers that have flexible by which their stems may be elevated in part by the twigs that grow on the plants. Besides, some of them have thorns or prickles that aid them to grip on another tress. These climbers have hooks that actively support them in ascending or leaning against the hosts [18]. There was only one species identified as hook climbers that were found in the study sites which was *Smilax calophylla* from Smilacaceae family.

(b) Tendrill climber

Tendrill is a slender wiry coiling part of climbers that can reach around themselves until they able to get support from other plants. The climber tendrills possess organs of varying morphology, sensitive to contact with the support to which they are actively attached, usually by curling around the other trees in order to obtain support [22]. There were two categories of tendrill vines which were stem tendrills and leaf tendrills. Stem tendrills are adapted by using the shoots that grow out the stem to coil on support plants. Meanwhile, leaf tendrills modified the leaves of climbers that emerge out the leaf nodes. The species that fallen on this category was *Thunbergia laurifolia*, *Friesodielsia lafifolia*, *Centrosema pubescens*, *Pueraria phaseoloides*, *Pueraria montana* and *Lygodium flexuosum*.

(c) Twiner

Twiner is referred to entire plant that twist around for a support until it becomes mature and rigid. Each kind of plant usually coils in only one direction [21]. This category was classified into twinning stems and twinning leaves by which twinning leaves used their leaves just like tendrills did to twist around the support plant. On the other part, twinning stems tend to wind around anything they touch. There were 18 species altogether that found as twiners which were *Parameria laevigata*, *Alyxia reinwardtii*, *Agelaea borneensis*, *Rourea minor*, *Agelaea macrophylla*, *Adenia macrophylla*, *Tetracera scandens*, *Dioscorea pyrifolia*, *Vigna umbellata*, *Spatholobus fenuginis*, *Gnetum cuspidatum*, *Tinomiscium petiolare*, *Pericampylus glaucus*, *Dapania racemosa*, *Gynochthodes coriacea*, *Hedyotis capitellata*, *Tetrastigma dichotomum* and *Nothocissus spicifera*.

(d) Root climber

The plants under this category preferred to climb by means of true roots. They applied their clinging stems to attach themselves to other stable plants. The climber species that fallen under this category were *Scindapus heredaceus*, *Stenochlaena palutris*, *Clidemia hirta*, *Ficus sagitata*, *Ficus villosa*, *Ficus apiocarpa*, *Ficus trichocarpa* and *Piper porphyrophyllum*.

4.0 Conclusion

In conclusion, there were 35 species from 20 climbers' families from four natural trails at Agro Techno Park, Universiti Malaysia Kelantan, Jeli campus. The distributional pattern of climbers' diversity is associated to alteration of ecological environment in study sites. The checklist of climbers' species and their climbing mechanisms were also recorded. This information could potentially serve as an indicator for predicting the distribution of host plants or other commonly associated species for conservation of climbers' species.

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