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The Distribution of Anacardiaceae in Teluk Bahang Forest Reserve, Pulau Pinang

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Abstrak: Kajian dijalankan dalam kawasan seluas 0.4 ha di Hutan Simpan Teluk Bahang, Pulau Pinang ke atas pokok berukuran ketinggian paras dada (DBH) ≥ 5 cm. Tujuh puluh lima individu Anacardiaceae (14% daripada jumlah semua pokok) direkodkan, diwakili oleh 4 genus dan 5 spesies iaitu *Mangifera pentandra*, *Mangifera macrocarpa*, *Gluta elegans*, *Campnosperma auriculatum* dan *Swintonia floribunda*. Purata kepadatan Anacardiaceae di dalam plot adalah 7.50±8.14 (min±S.D.) per ha dengan keluasan pangkal 0.97 m²/0.40 ha dan nilai kepentingan (IV_i) 81%. Nilai anggaran biojisim atas tanah Anacardiaceae adalah 24.24 tan/0.40 ha. Di samping itu, sejumlah 333 juvenil pokok Anacardiaceae dengan ukuran DBH < 5 cm telah direkodkan dan dikenalpasti daripada genera *Gluta* (9.99%), *Swintonia* (84.90%) dan *Mangifera* (5.11%).

Kata kunci: *Mangifera*, *Gluta*, *Campnosperma*, *Swintonia*, Purata Kepadatan, Keluasan Pangkal, Nilai Kepentingan, Nilai Jumlah Biojisim Atas Tanah

Abstract: To investigate the distribution of Anacardiaceae in Teluk Bahang Permanent Forest Reserve (TBPFR) in Pulau Pinang, all trees with a diameter at breast high (DBH) ≥ 5 cm were enumerated in a study site constituting 0.4 ha of the reserve. Seventy five individuals of Anacardiaceae (14% of all trees) are recorded. These individuals represent 4 genera and 5 species, namely, *Mangifera pentandra*, *Mangifera macrocarpa, Gluta elegans*, *Campnosperma auriculatum* and *Swintonia floribunda*. The mean density of Anacardiaceae within the study plots is 7.50±8.14 (mean±S.D.) per ha whereas the basal area (BA) calculated is 0.97 m²/0.40 ha. The importance value (IV_i) for Anacardiaceae is 81%. The estimated total aboveground biomass (TAGB) for Anacardiaceae is 24.24 ton/0.40 ha. A total of 333 Anacardiaceae saplings with a DBH < 5 cm are recorded. These saplings have been identified as juveniles of the genera *Gluta* (9.99%), *Swintonia* (84.90%) and *Mangifera* (5.11%).

Keywords: *Mangifera*, *Gluta*, *Campnosperma*, *Swintonia*, Mean Density, Basal Area, Importance Value, Total Aboveground Biomass

INTRODUCTION

An early study of the Anacardiaceae in Malaysia was conducted by Ding Hou (1978). A revision of the classical taxonomy of the group has recently appeared (Kiew *et al*. 2010). In addition, research on Anacardiaceae has been conducted at the molecular level (e.g., Mitchel *et al.* 2006). Studies of the medicinal properties of species within the Anacardiaceae have also been conducted worldwide (e.g., Himejima & Kubo 1991; Elof 2001). According to Hartley (1998),

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76 genera and more than 600 species of Anacardiaceae occur worldwide. These species are found primarily in tropical countries. A few species occur in temperate areas. Seventeen of these genera, with a total of 77 species, occur in Peninsular Malaysia. Fifteen of these Anacardiaceae species are endemic to this area (Anon. 1996). According to Turner (1989), Anacardiaceae is the second most frequently recorded family in Pulau Pinang National Park. Asyraf (2003) commented that *Gluta* is widely distributed in this locality.

According to Kochummen (1989), the greatest biodiversity shown by the family Anacardiaceae in any major tropical area occurs in Malaysia. The greatest number of endemic taxa in this family are found in Peninsular Malaysia and Borneo. The family includes 16 genera and 74 species indigenous to Peninsular Malaysia alone. These representatives of the family range from lowlands to mountain forests. Certain species, such as *Gluta curtisii* and *Swintonia schwenkii*, appear to grow gregariously in the hill and upper dipterocarp forests (Kochummen 1989). Moreover, in the lowland forest of the Sungai Menyala Forest Reserve located in Negeri Sembilan, Anacardiaceae is one of the most common families of trees with a diameter at breast height (DBH) of 10 cm or higher and is represented by 7 genera, 8 species and 38 individuals (in one hectare of study area) (Kochummen 1989).

The main objectives of this study are to determine the genera and species of Anacardiaceae in Teluk Bahang Permanent Forest Reserve (TBPFR) and to estimate the density and distribution pattern of Anacardiaceae. This study is necessary because few studies of Anacardiaceae have previously been conducted. In particular, there is a need for studies of the distribution and ecological characteristics of the family. Therefore, it is also recommended that further research should be conducted to study the function of Anacardiaceae in a forest ecosystem. The data compiled in this study should contribute to a more detailed understanding of the density and distribution of Anacardiaceae in Pulau Pinang and in Malaysia as a whole.

MATERIALS AND METHODS

Study Site

TBPFR is located north of Pulau Pinang (5°27’02.15”N, 100°13’07.75”E) and is bordered by coastline and human settlements. The reserve covers an area of 873 hectares. Within the area, 32 hectares was gazetted as recreational forest (Zakaria & Yusoff 2002). The location of the plots used in the current study and the vegetation types characteristic of the plots are shown in Table 1. Zakaria and Yusoff (2002) also stated that most of the forest was selectively logged in the early 1930s. Some parts of the forest are reserved and have never been logged.

Species Assessment

A total of 10 plots were established (20 m x 20 m each). Subsequently, these plots were further divided into 4 subplots, each 10 m x 10 m, for dispersion analysis. The DBH of all trees in the plots is measured with a measuring tape.

Table 1: Details of the 10 study plots and dispersion pattern of Anacardiaceae in TBPFR, Pulau Pinang.

Plot	Geographical location	Vegetation type	ID	IC	GI	Dispersion
1	N05° 26.823' E100º 13.246'	Old secondary forest	2.46	1.46	0.15	Random
2	N05° 26.820 E100° 13.229'	Old secondary forest	2.33	1.33	0.05	Random
3	N05° 26.592' E100° 13.412'	Old secondary forest	3.41	2.41	1.21	Clumped
4	N05° 26.568' E100° 13.399'	Old secondary forest	2.58	1.58	0.23	Random
5	N05° 26.579' E100° 13.336'	Reserved forest	2.69	1.69	0.34	Random
6	N05° 26.561' E100° 13.307'	Reserved forest	3.41	2.41	1.21	Clumped
7	N05° 26.613' E100° 13.264'	Reserved forest	–	–	–	Not present
8	N05° 26.538' E100° 13.239'	Reserved forest	–	–	–	Not present
9	N05° 26.789' E100° 13.342'	Old secondary forest	2.42	1.42	0.11	Random
10	N05° 26.652' E100° 13.279'	Old secondary forest	2.99	1.99	0.66	Random

Notes: ID is Index of Dispersion, IC is Index of Clumping and GI is Green's Index (Ludwig & Reynolds 1988).

Trees with a DBH < 5 cm are considered to be juvenile or small trees whereas trees with a DBH $\geq$ 5 cm were considered to be adults. Most trees with a DBH $\geq$ 5 cm belonging to the Anacardiaceae are observed to produce fruits. King *et al.* (2006) state that most individuals with a DBH less than approximately 5 cm were considered to be juveniles. These individuals likely allocate substantial biomass to stem growth rather than to reproduction. This pattern is found in most woody species. The locations of all trees belonging to the Anacardiaceae in each sub-plot are plotted on graph paper to determine their distribution pattern. The species identification of Anacardiaceae was based on Kochummen (1996, 1997). The calculations of the density and basal area (BA) are based on Husch *et al*. (1995). The calculation of the importance value (IV_i) is based on Zakaria (2008) and Nizam *et al*. (2006). The calculation of the total aboveground biomass (TAGB) is based on Okuda *et al*. (2004). The distribution pattern of Anacardiaceae in the study plot is determined by calculating the Index of Dispersion [ID (the variance-to-mean ratio)] with the formula ID = S2/x, where S2 is the variance and x is the mean. The Index of Clumping (IC) is given by IC = ID – 1. The Green Index (GI) is calculated with the expression IC/ (n – 1), where n is the total number of individuals or samples (Ludwig & Reynolds 1988). The calculated value of the GI for each study plot is considered the dispersion pattern of Anacardiaceae within the respective plot. The values of the GI range from 0

(random) to 1 (maximum clumping). The main seedling distribution is determined by calculating the total percentage of each species present within the study plot. Voucher specimens collected are deposited in the herbarium of the School of Biological Sciences, Universiti Sains Malaysia, Pulau Pinang.

RESULTS AND DISCUSSION

A total of 542 trees with a DBH of more than 5 cm were recorded from 10 study plots (0.40 ha). By extrapolation, this figure corresponds to 1355 individuals per ha (extrapolation) in TBPFR. In addition to Anacardiaceae, the principal families recorded are Dipterocarpaceae, Euphorbiaceae, Myrtaceae, Rubiaceae and Moraceae. This result is consistent with the findings of Zakaria (2008). In the present study, 14% of all the trees recorded belong to Anacardiaceae. *Mangifera pentandra*, *M. macrocarpa*, *Gluta elegans*, *Campnosperma auriculatum* and *Swintonia floribunda* are the species of Anacardiaceae recorded from the study plots.

S. floribunda is the most dominant species of Anacardiaceae in the study plots. In contrast, the study by Zakaria (2008) in the same forest finds that the dominant species of Anacardiaceae is *Gluta curtisii*. The reason for this difference may be that study plots were established in different portions of the forest. Zakaria (2008) established study plots at lower elevations (80–100 m) whereas the plots used in this study were established at elevations of 150–200 m. In the reserve, other species of Anacardiaceae were also observed outside the study plots, along the forest trails. These species included *Gluta walichii, Gluta aptera*, *Gluta curtisii, Gluta renghas, Buchanania sessifolia* and *Mangifera griffithii*. This result is consistent with the finding of Zakaria (2008) that high numbers of species and individuals of Anacardiaceae occur in TBPFR but that their distribution is uneven.

Trees with small DBH are more abundant than trees with large DBH (Fig. 1). The reverse-J curve shown by the graph of these data suggests that the data distribution is not normal. According to Nizam *et al*. (2006), this pattern is common in primary rain forests with many saplings and fewer large trees. However, TBPFR is an old disturbed forest. Accordingly, Zakaria (2008) suggested that this forest is at a late stage of recovery. The forest structure is similar to a climax forest with a continuous canopy, tall trees and low light penetration. For this reason, the number of juveniles is much greater than the number of adult trees (Table 2 and Fig. 2).

The number of Anacardiaceae in the study plots is low in relation to the numbers of other species (Fig. 1). The mean distribution of Anacardiaceae in the 0.4 ha study plot is only 7.50±8.14 (mean±S.D.). The density of mature Anacardiaceae in TBPFR is only 190 trees per ha (extrapolated data). According to Fangliang *et al*. (1997), population densities in tropical rain forests are usually low, and the nearest-neighbour distances among conspecific trees are relatively large. This pattern is hypothesised to decrease the probability of intraspecific interactions.

The basal area (BA) value found by this study shows that Anacardiaceae covers only a small portion of the 0.4 ha study plot. The BA is influenced by the DBH of the tree. A higher DBH produces a higher BA (Husch *et al.* 1995). Anacardiaceae only covers 0.97 m²/0.40 ha (8.41%) of the total BA of the study plot or a total of 2.43 m² per ha in TBPFR. The mean BA per plot for the 4 principal genera is shown in Figure 3.

The value of the BA is related to the value of the TAGB (Okuda *et al*. 2004). In this study, *G. elegans* was found to have the highest TAGB (Table 2). This value is influenced by the DBH and by the height of the tree. The total IV_i for Anacardiaceae relative to all trees in the study plot is 81.1. *S. floribunda* has the highest IV_i of the Anacardiaceae species (Table 2).

Table 2: TAGB and IV_i for species of Anacardiaceae (DBH > 5 cm) in TBPFR, Pulau Pinang study plots.

Species of Anacardiaceae	No. of trees	Mean of BA (m²/0.40 ha)	TAGB (tons/0.40 ha)	IV_i
Swintonia floribunda	50	0.55	9.90	167.79
Gluta elegans	13	0.37	12.43	77.2
Mangifera pentandra	10	0.05	1.30	40.39
Mangifera macrocarpa	1	0.01	0.32	7.59
Campnosperma auriculatum	1	0.01	0.29	7.54
Total	75	0.99	24.24	300

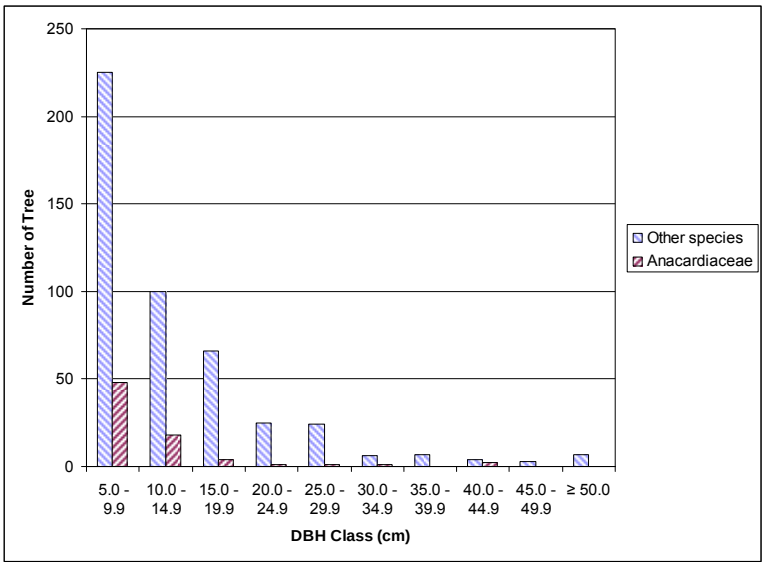

Figure 1: Frequency distribution of Anacardiaceae and other species by DBH class in a 0.40 ha study area in Pulau Pinang.

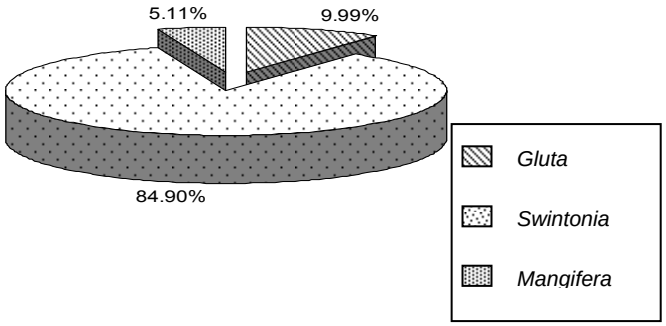

Figure 2: Percentage of Anacardiaceae juveniles for the genera *Swintonia*, *Gluta* and *Mangifera* in a 0.4 ha study area in TBPFR, Pulau Pinang (total number of small trees, DBH < 5 cm = 333).

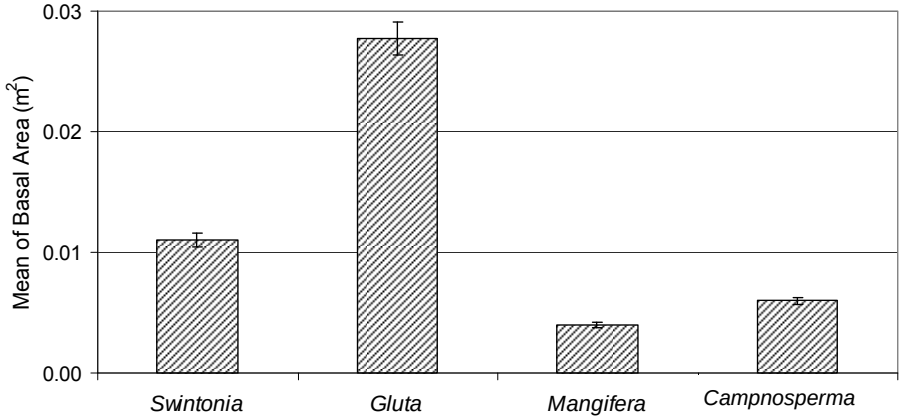

Figure 3: Mean BA of the genera *Swintonia*, *Gluta*, *Mangifera* and *Campnosperma* in a 0.40 ha study area in TBPFR, Pulau Pinang.

The calculation of the dispersion pattern based on the dispersion indices (i.e., ID, IC and GI), suggested that in general, Anacardiaceae is randomly distributed in TBPFR. Six plots show random dispersion whereas two plots show a clumping pattern (Table 1). According to Kochummen (1996), Anacardiaceae seeds or fruits generally consist of drupes or winged fruits and are therefore dispersed by wind, mammals and water. Thus, the distribution of Anacardiaceae is random (Fig. 4 and 5). The dispersal mechanisms used by the family produce a distribution pattern in which the distances between individuals are relatively large. The clumping dispersion pattern indicated by the dispersion indices in Plots 3 and 6 (Table 1) could be a result of the topographical and geophysical structure of the two plots. These plots are located at the bottom of a slope-like

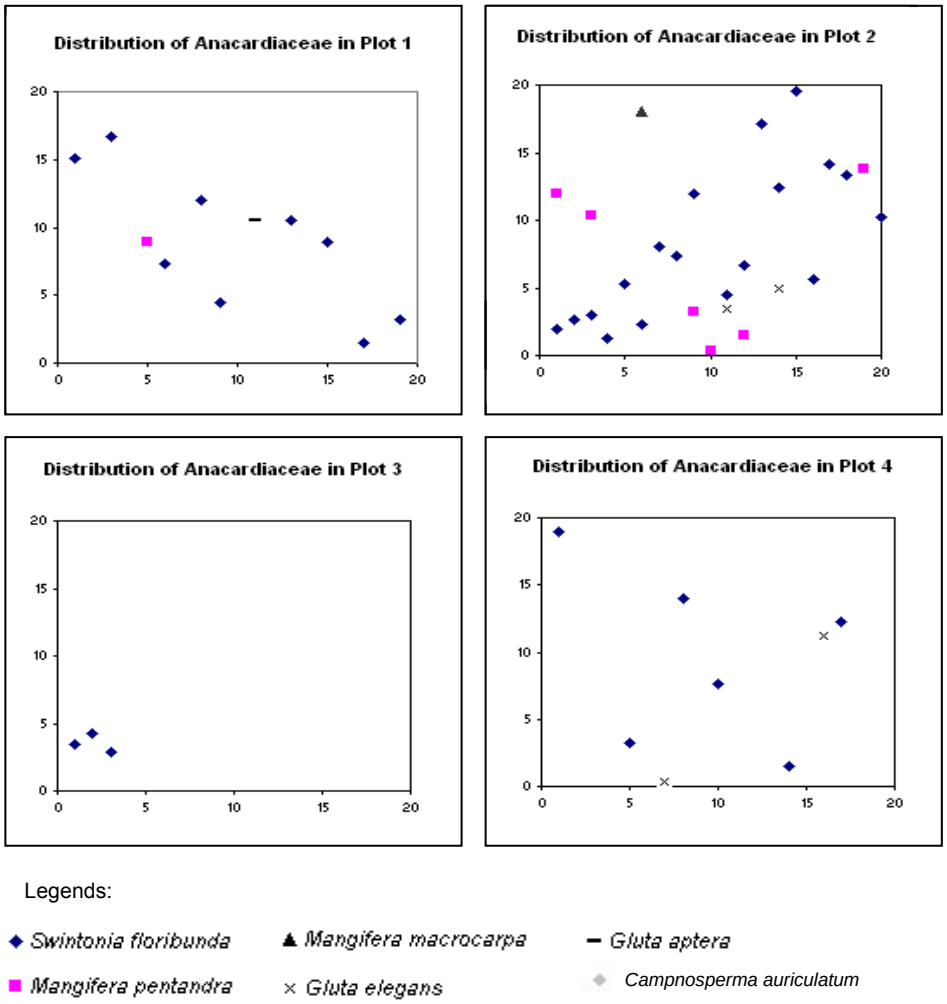

Figure 4: Distribution of Anacardiaceae (DBH > 5 cm) in Plot 1, Plot 2, Plot 3 and Plot 4 in TBPFR, Pulau Pinang (plot measurement in m^2).

area. Seeds from the parent plants could be deposited in these plots by the runoff of rain water from the surface. In contrast, no Anacardiaceae were found in Plot 7 or Plot 8, which are covered primarily by rocky substrate. The rocky conditions may have prevented the successful establishment of Anacardiaceae in this area. In addition, the seedlings may not have been able to establish themselves because of post-dispersal seed herbivory (Hulme 1998; Alcántara *et al.* 2000) or competition with other species for nutrients, space, and other requirements for growth and survival. According to Lack and Evans (2001), these factors have an overriding influence on the distribution of a species within one geographical region and can affect major distribution patterns. Furthermore,

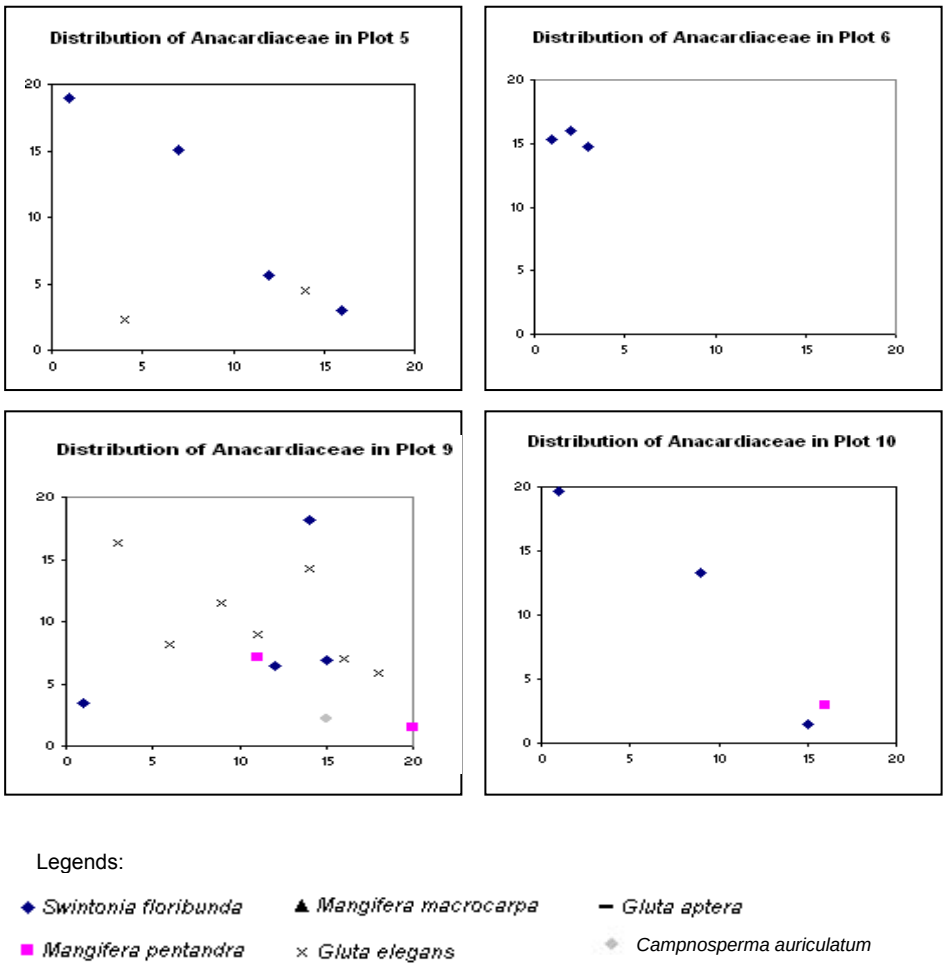

Figure 5: Distribution of Anacardiaceae (DBH > 5 cm) in Plot 5, Plot 6, Plot 9 and Plot 10 in TBPFR, Pulau Pinang (plot measurement is in m^2).

according to Vickery (1984), the survival rate of plant roots in areas with less soil is low because the roots may fail to develop in the limited soil space.

The results for the abundance of smaller Anacardiaceae individuals show that juvenile *Swintonia* (84.90%) is most frequently recorded in the study area, followed by juvenile *Gluta* (9.99%) and *Mangifera* (5.11%). *Campnosperma* juveniles are not present (Fig. 3). A total of 333 Anacardiaceae juveniles are recorded. *S. floribunda* is the dominant Anacardiaceae species recorded within the study plot and shows the highest importance value. This finding may result from the presence of many adult *S. floribunda* trees. The presence of these adult trees influences the number of recorded saplings/juveniles. Moreover, this species produces fruits throughout the year (Ng & Phil 1989).

CONCLUSION

The results of this study suggest that the family Anacardiaceae is randomly distributed in TBPFR, Pulau Pinang. Geographical variation within the study plots could contribute to the spatial distribution pattern found for this family. The number of juveniles is high because the forest is a recovering secondary forest at a late stage of growth. The establishment of larger study plots for further study is recommended. The contribution of Anacardiaceae to the forest ecosystem should be investigated.

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