Preliminary Study on Tree Species Composition, Diversity and Biomass of *Dipterocarpus* and *Hopea* genera of Bukit Bakar Forest Eco Park, Machang, Kelantan

IOP Conf. Series: Earth and Environmental Science **549** (2020) 012037 doi:10.1088/1755-1315/549/1/012037

Preliminary Study on Tree Species Composition, Diversity and Biomass of *Dipterocarpus* and *Hopea* genera of Bukit Bakar Forest Eco Park, Machang, Kelantan

Nurafiqah Zafriakma[1], Noor Shuhada Masran[1], Dini Dayana Ahmad[1], Muhammad Ikram Nazli[1], Radhiah Zakaria[2], Muhammad Firdaus Abdul Karim[1] and Nazahatul Anis Amaludin[1*]

[1] Faculty of Earth Science, Universiti Malaysia Kelantan, Jeli Campus, 17600 Jeli, Kelantan.
[2] Faculty of Public Health, University Muhammadiyah Aceh, Indonesia

E-mail: nazanis@umk.edu.my

Abstract. A study on species composition, diversity and biomass of genera *Dipterocarpus* and *Hopea* at Bukit Bakar Forest Eco Park, Machang, Kelantan was conducted. A total of 5 ecological plots with measurement of 20 m x 20 m were established. All trees with diameter at breast height (dbh) less than 5.0 cm were tagged, measured and collected for specimen identifications and voucher specimen's preparations. The floristic composition of Bukit Bakar Eco Park consists of 135 individuals represented by 1 family, 2 genera and 17 species. The most abundance species recorded was *Dipterocarpus crinitus* Dyer with 23 individuals were recorded. *Dipterocarpus crinitus* (Dipterocarpaceae) was the most important species according to Important Value index (IV*i*) calculated at IV*i* = 17.73%. Dipterocarpaceae was the most high species diversity according to Shannon Wiener Index, H'=2.02 (H'_{max} =2.30) for *Dipterocarpus spp*. and H'=1.90 (H'_{max} =1.94) for *Hopea spp*. and Simpson's Index of Diversity for *Dipterocarpus spp*. is 0.85 and 0.86 for *Hopea* spp.. Whilst *Hopea* had a slightly higher Species Evenness Index (E_H=0.98) compared to *Dipterocarpus* (E_H=0.87). Total tree biomass estimation in the study area was at 145.18 t/ha.

1. Introduction

In Malaysia, Dipterocarpaceae is known as economical timber trees and they serve as proxy to the forest such as preserving the biodiversity and absorbing CO_2 concentration. Out of all vegetation type in Malaysia rainforest, lowland rainforest is the most highly diverse vegetation compared to others [1,2]. Dipterocarpaceae dominates the tropical over 30% of the basal area or over 40% in emergent area [3].

In plant community ecosystem, there are two critical parameters in plant community ecosystem which are biodiversity and biomass [4]. The biodiversity-biomass relationship has become a major ecological focus worldwide over recent decades [5,6]. Tropical rainforest plays vital roles in maintaining human life by providing water resources, food, medicine, oxygen and also absorb the carbon dioxide in the atmosphere which can reduce the amount of pollution that can effects in global warming, thus disturbing our biodiversity in the forest. It is very crucial to maintain the diversity

contain in our forest but they are now becoming smaller and fragmented due to human activities such as uncontrollable logging and shifting cultivation which leads to forest degradation thus, bring to the loss of habitat for flora and fauna.

For instance, Ulu Sat Forest Reserve (USFR) has been gazetted as protection forest for water reservoir by Kelantan State in 2019. While Bukit Bakar Forest Eco Park, is one of three eco park in Kelantan; i.e. Jeram Linang and Telaga Tujuh. As recreational forest, the stress put onto these forests in terms of conservation increases in conjunction with tourism activities. It has led to pollution like littering, solid waste dumping and water pollution. Thus, it is crucial to document the species composition, diversity and tree biomass of these recreational forest to show whether the implementation of PRFs in Peninsular Malaysia helps to mitigate species loss or otherwise. However, there are just few studies done in Bukit Bakar Forest Eco Park. The data of this study will help to value the important of this forest.

2. Materials and Methods

2.1 Study area and tree enumeration

Bukit Bakar Forest Eco Park, Machang is located in the Bukit Bakar Forest Reserve (Figure 1). It is situated at 5.7182°N, 102.2598°E and covers an area of 3.14 hectares that managed under Forestry Department Kelantan. A total of five plots of 20 m x 20 m were established and trees with diameter at breast height (dbh) with ≤ 5 cm were enumerated and identified. Each plot locations details such as coordinate and altitudes are summarised in Table 1. Bukit Bakar Forest Eco Park is lowland dipterocarps forest with ranging altitudes between 300-700 m above sea level (a.s.l). In each plot, all trees with diameter at breast height (dbh) with ≤ 5 cm were measured and tagged. Leaves specimens of each measured tree were collected for preparation of voucher specimens and for species identification. Species identification was based on keys in *Tree Flora of Sabah and Sarawak* Volume 5 [7], Malaysia Plant Red List: Peninsular Malaysian Dipterocarpaceae [8] and with assistance of experienced botanists.

2.2 Data Analysis

All identified trees were tabulated according to family, genus and species. Ecological parameters considered in this study were species composition, basal area, relative abundance and species diversity indices. Formula proposed by [9] were used in this study:

a) Basal area (BA)
$= 0.7857 \times D^2$ (3.1)
Where:
D = DBH (cm)

b) Above ground biomass (AGB)
$= W_s + W_b + W_l$, (kg) (3.2)

c) The importance of family and species in the community were determined by calculating the Importance Value Index (IV*i*) and summing parameters, such as relative density (R_d), relative dominance (R_D) and relative frequency (R_f) [10].
$= IV_i = R_F + R_d + R_D$ (3.3)

d) Tree species diversity at the study area was determined using Shannon-Wiener's Index (H') [11].
$H' = -\sum_{i=1}^{s} p_i \ln p_i$ (3.4)
Where:
s = number of species
pi = the proportion of individuals or the abundance of the its species expressed as proportion of total abundance
ln = log base n

e) Species Evenness (E) is calculated based on formula by Pielou's Evenness Index [12].
$E_H = H' / H'_{max} = H' / \log S$ (3.5)
Where:
S = Total number of species in the sample
H' = Shannon-Weiner diversity index

f) Simpson's Index (D) [13].
$D = \frac{1}{\sum_{i=1}^{s} pi^2}$ (3.6)

3. Results and Discussion

3.1 Floristic Composition

A total 135 trees with diameter at breast height of less than 5 cm were censused in five plots at Bukit Bakar Forest Eco Park, Machang comprising of 17 species, two genera and one family. The distributions of each species corresponded with their natural habitat where some species were found at the elevation below from 400 m while some species can be found up to 800 m. Table 2 shows the total number of individuals for all species found in Bukit Bakar Forest Eco Park and its natural habitat as mentioned by [8]. Thus, it proves the statement from [14], where the natural territory of most of the *Dipterocarpus spp*. and *Hopea spp*. was at wet lowland evergreen rainforest.

According to [15], species abundance is related to the species richness. Table 2 shows the data analysis of species abundance of genera *Dipterocarpus* and *Hopea* in the study area. In that table, it demonstrates that *Dipterocarpus crinitus* Dyer has the highest abundance followed by *Dipterocarpus baudii* Korth and *Dipterocarpus cornutus* Dyer. This is because most of the area in Bukit Bakar Forest Eco Park was sandy clay soil, which it was suitable habitat for this species to be occurred.

Therefore, during the data collection, most of the species presence was *D.baudii, D.crinitus* and *D.cornutus*. However, *Dipterocarpus caudatus* Foxw. ssp. *Penangianus* (Foxw.) P.S.Ashton had the lowest value of species abundance in that study area. This is because the optimum habitat for this species was on the area that has type of soil which is flooded sandy clay alluvium. Bukit Bakar Forest Eco Park probably was not suitable for the growing of *D.caudatus* Foxw. ssp. *Penangianus* (Foxw.) P.S.Ashton. However, species distributions are also strongly aggregated with respect to variation in topography, soil water and soil nutrient status [16,17,18,19].

Trees with dbh ≤ 5 cm were censused because most of trees in the study area are observed in small dbh. Whilst, *Hopea spp*. of which had lower abundance compared to *Dipterocarpus spp*., these values was divergent for each species because of few factors, it may due to the gap formation. There were various amount of gap can be found in the Bukit Bakar Forest Eco Park, one of the example for gap formation was lightning gap. These gaps have influences or interference the presence of species frequency by develop species heterogeneity [20].

3.2 Importance Value Index (IV_i)

The Importance Value Index (IV_i) is one of the importance calculations for this study. The IV_i values frequently applied in the ecological studies to determine the value of any species toward the ecological significance. Based on Table 2, it shows that *Dipterocarpus crinitus* Dyer has the highest IV_i=17.73 while *Dipterocarpus sublamellatus* Foxw. and *Hopea beccariana* Burck both have the lowest value IV_i=4.89.

Species that have the highest important value index indicate that they have higher relative dominance than other species that were found in the study area. According to Dash et al. [21], the highest IV_i value in the study area represent an absolute dominance in the tree layering. Species that have low IV_i may be influenced by few factors such as poor distribution in the study area or the competition that exist between that species with other species from different families [22].

Table 1. Summary of each plots locations in the study area.

Plots	Coordinates		Elevation (m) above sea level
	Latitude	Longitude	
1	05°43.203'N	102°15.630'E	92.4
2	05°43.009'N	102°15.715'E	137.2
3	05°43.030'N	102°15.718'E	143.1
4	05°43.038'N	102°15.714'E	132.7
5	05°42.666'N	102°15.956'E	235.1

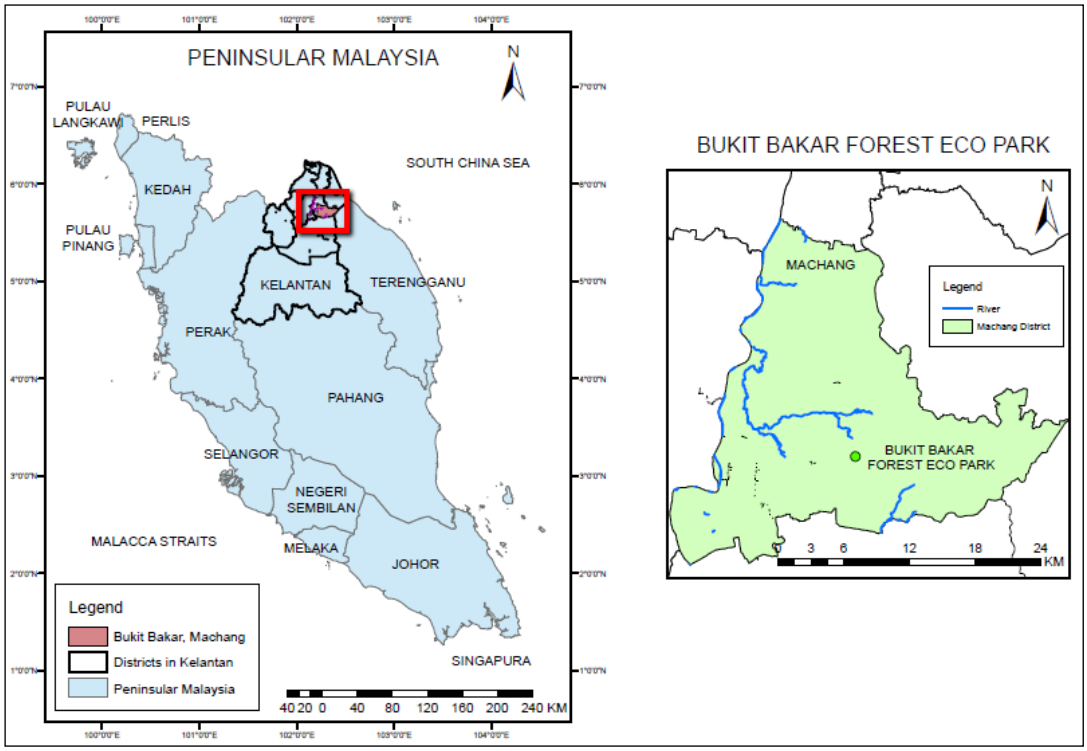

Figure 1. Map of Bukit Bakar Eco Park, Machang showing the location of study area.

3.3 Species Diversity

The value of all diversity indices used to calculate the diversity is summarised in Table 3. The values for both Shannon-Wienner's Index (H') usually ranges between 1.5 to 3.5, although in exceptional cases, the value can exceed 4.5 and above [23]. Therefore, (H') values for *Dipterocarpus* and *Hopea* found in this study were almost 2.0. Based on the Species Evenness Index (E) of the two genus are closely to 1, i.e *Dipterocarpus* (E_H=0.87) and *Hopea* (E_H=0.98). This means that the diversity of genera *Dipterocarpus* and *Hopea* are mostly diverse in Bukit Bakar Forest Eco Park. While, the values for Simpson's Index (D) was similarly same for *Dipterocarpus* (D=0.85) and *Hopea* (D=0.86) that indicate the richness or abundance of *Dipterocarpus spp*. and *Hopea spp*. in Bukit Bakar Eco Park.

Dipterocarpaceae was not only was demonstrated high species diversity in this study but also in previous studies in Peninsular Malaysia. For instance, at Bangi Permanent Forest Reserve, the species diversity recorded for one ha study plot was 6.99 (H'_{max}=7.45) with the evenness of 0.85 [24]. The value was higher compared to this study. However, the diversity of trees sampled in different ecosystems may vary. At a Redang Island from two plots of 0.1 ha showed the Shannon-Weiner

Diversity Index (H') was considered high in both forest plots with 3.4 (H'_{max} = 3.9) at the coastal forest and 3.5 (H'_{max} = 4.0) at the inland forest.

Table 2. List of genera *Dipterocarpus spp*. and *Hopea spp*. according to their number of trees and Importance Value Index (IV*i*) in Bukit Bakar Forest Eco Park.

Genus	Species	No. of trees	Ind/ha	IV*i* (%)
Dipterocarpus	*Dipterocarpus acutangulus* Vesque	7	35	8.1
	Dipterocarpus baudii Korth.	20	100	17.16
	Dipterocarpus caudatus Foxw. ssp. *Penangianus* (Foxw.) P.S.Ashton	2	10	5.02
	Dipterocarpus chartaceus Symington	5	25	7.35
	Dipterocarpus cornutus Dyer	13	65	13.52
	Dipterocarpus crinitus Dyer	23	115	17.73
	Dipterocarpus grandiflorus (Blanco) Blanco	4	20	6.12
	Dipterocarpus kerrii King	8	40	8.32
	Dipterocarpus sublamellatus Foxw.	3	15	4.89
	Dipterocarpus verrucosus Foxw. *ex* Slooten	4	20	6.12
Hopea	*Hopea beccariana* Burck	3	15	4.89
	Hopea odorata Roxb.	8	40	8.14
	Hopea latifolia Symington	9	45	8.80
	Hopea glaucescens Symington	8	40	8.32
	Hopea mengerawan Miq.	5	25	6.32
	Hopea pachycarpa (F.heim) Symington	7	35	8.12
	Hopea apiculata Symington	6	30	6.84
		135	**675**	

Table 3. The values of diversity indices that used for genera *Dipterocarpus* and *Hopea* in Bukit Bakar Forest Eco Park Machang, Kelantan.

Diversity Indices	*Dipterocapus* spp.	*Hopea* spp.
Shannon-Wiener's Index (H')	2.02	1.90
Shannon- Wiener's Maximum Index (H'_{max})	2.30	1.94
Species Evenness Index (E_H)	0.87	0.98
Simpson's Index (D)	0.85	0.86

3.4 Biomass

The total tree biomass estimated at the Bukit Bakar Forest Eco Park was 145.18 t/ha. A total of 69.07% of the total biomass was contributed by *Dipterocarpus* (100.28 t/ha) and followed by *Hopea* (44.9 t/ha). At species level, *Dipterocarpus* spp. highly influenced the total biomass estimated at Bukit Bakar Forest Eco Park, specifically *Dipterocarpus kerrii* King which contributed the most with 28.71 t/ha and followed by *Dipterocarpus cornutus* Dyer with 23.28 t/ha. Dipterocarpaceae dominated the biomass as the size of the trees enumerated from the respective study plots were large compared to *Hope*a. This is may consider because one factor that may influence the biomass content is dbh [25].

4. Conclusion

Based on the floristic pattern and species diversity calculation two genera *Dipterocarpus* and *Hopea showed* that Bukit Bakar Eco Park had a high diversity and density of tree species. Even though the study area was small, it proved that both genera *Dipterocarpus* and *Hopea* contains high floristic

composition that consist of high frequency, density and abundance. As one of the main eco park sites in Kelantan, the habitat disruption has a higher tendency to be happened especially contributed by human activities. The above ground biomass showed *Dipterocarpus* spp. had high above ground biomass although the dbh of trees ≤ 5 cm. These data would be useful to a proper management and conservation strategy for this area and to maintain its function as water reservoir for several districts in Kelantan. The results from this study can be used as a basic guideline for other ecological studies on the whole Ulu Sat Forest Reserve (USFR), especially the study of the involving a larger landscape in the future.

Acknowledgements
The authors would like to thank the Forestry Department of Peninsular Malaysia, Forestry Department of Kelantan for allowing us to conduct this study in Bukit Bakar Forest Eco
Park, Machang, Kelantan and assistance on the ground En Mohammed Firdaus Mohd Ridzuan, Dr. Radhiah Zakaria for their assistance in the field work and plant identifications; and Faculty of Earth Science, Universiti Malaysia Kelantan for the support granted throughout the study.

References
[1] Whitmore T C 1984 *Tropical rain forests of the Par East* (Oxford: Clarendon Press)
[2] Richards P W 1952 *The Tropical Rainforest* (Landon: Cambridge University Press)
[3] Manokaran N and Swaine M D 1994 Population Dynamics of Trees in Dipterocarp Forest of Peninsular Malaysia. *Malayan Forest Records*, 173.
[4] Guo Q F 2007 The diversity-biomass-productivity relationships in grassland management and restoration. *Basic & Applied Ecology* **8** 199–208.
[5] Liang J J, Crowther T W, Picard N, Wiser S, Zhou M and Alberti G 2016 Positive biodiversity-productivity relationship predominant in global forests. *Science* **354** 196–210.
[6] Wu X, Wang X P, Tang Z Y, Shen Z H, Zheng C Y and Xia X L 2015 The relationship between species richness and biomass changes from boreal to subtropical forests in China. *Ecography,* **38**, 602–613.
[7] Soepadmo E, Saw L G and Chung R C K 2004 Tree Flora of Sabah and Sarawak, Volume 5. Sabah Forestry Department, Forest Research Institute Malaysia (FRIM), Sarawak Forestry Department, Malaysia. pp. 528.
[8] Chua L S L, Suhaida M, Hamidah M and Saw L G 2010 Malaysia Plant Red List: Peninsular Malaysian Dipterocarpaceae. *Research Pamphlet No. 129*. Forest Research Institute Malaysia, Kepong.
[9] Kato, R., Ogawa, H., Takadi, Y. (1978). Plant biomass and growth increment studies in Pasoh Forest. *Mal. Nat. Journal* **30**(2): 211-224.
[10] Brower, J.E., Zar, J.H. & Ende, C.N. (1997). Field and Laboratory Methods for General Ecology. *4th Ed*. Boston: McGraw Hill.
[11] Shannon C 1948 A mathematical theory of communication *Bell Syst. Tech. J.* **27** 379–423.
[12] Pielou E C 1966 The measurement of diversity in different types of biological collections *Journal of Theoretical Biology* **13** 131–144
[13] Simpson E H 1949 Measurement of diversity *Nature* **163** 688
[14] Ashton P S 1982 Dipterocarpaceae *Flora Malesiana* **Series I** 237-552.
[15] Stirling G and Wilsey B 2001 Empirical relationships between species richness, evenness, and proportional diversity *The American Naturalist* **158** 286-300.
[16] Svenning J C 2001 On the role of microenvironmental heterogeneity in the ecology and diversification of Neotropical rain-forest palms (Arecaceae) *Botanical Review* **67** 1–53.
[17] Clark D B, Clark D A and Read J M 1998 Edaphic variation and the mesoscale distribution of tree species in aneotropical rain forest *Journal of Ecology* **86** 101–112.

[18] Swaine M D 1996 Rainfall and soil fertility as factors limiting forest species distributions in Ghana. *Journal of Ecology* **84** 419–28.
[19] Duivenvoorden J F 1995 Tree species composition and rain forest–environment relationships in the middle Caqueta, Colombia, NW Amazon *Vegetatio* **120** 91–113.
[20] Manabe T, Shimatani K, Kawarasaki S, Aikawa S and Yamamoto S 2009 The patch mosaic of an old-growth warm-temperate forest: patch-level descriptions of 40-year gap-forming processes and community structures *Ecological Research* **24** 575–86.
[21] Dash S K, Kulkarni M A, Mohanty U C and Prasad K 2009 Changes in the characteristics of rain events in India *J Geophys Res* **114** D10109.
[22] Comita L, Condit R and Hubbell S 2007 Developmental changes in habitat associations of tropical trees *Journal of Ecology* **95**(3) 482–492.
[23] Magurran A E 2004 Measuring Biological Diversity Ch4. *Measuring Biological Diversity*, 256.
[24] Lajuni J J and Latiff A 2013 Biomass and Floristic Composition of Bangi Permanent Forest Reserve, a Twice-Logged Lowland Dipterocarp Forest in Peninsular Malaysia *Sains Malaysiana* **42**(10) 1517–21.
[25] Bao H, Krishna P P and Hailemariam T 2016 Aboveground biomass equations for evergreen broadleaf forests in South Central Coastal ecoregion of Viet Nam: Selection of eco-regional or pantropical models *Forest Ecology and Management* **376** 276-83.