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Tree species composition, diversity and aboveground biomass of two forest types at Perhentian Island, Peninsular Malaysia

M. Khairil[1,2,3], A. Noor Ain[2], M. Salmah[2], A. Nur Faranazuha[2], K. Moneruzzaman[2], Y. Nornasuha[2], A. Nur Azalina[2], I. Azimah[3], R. Noor-Amalina[4] and M.S. Razali[5]

[1]Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Seri Kembangan, Selangor, **Malaysia**
[2]Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200, Besut, Terengganu, **Malaysia**
[3]East Coast Environmental Research Institute (ESERI), UniSZA KAmpus Gong Badak, 21300 Kuala Nerus, Terengganu, **Malaysia**
[4]Faculty of Health Science, Universiti Kebangsaan Malaysia Kampus Kuala Lumpur**,** Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, **Malaysia**
[5]School of Marine and Environmental Sciences (PPSMS), Universiti Malaysia Terengganu (UMT), 21300, Kuala Terengganu, Terengganu, **Malaysia**
***Correspondence: khairilmahmud@upm.edu.my** **Received: 14-10-2019, Revised: 21-11-2019, Accepted: 23-11-2019 e-Published: 16-01-2020**

Perhentian Island is a famous ecotourism site in Terengganu, Peninsular Malaysia. However, the increase in tourism activities such as chalets development and deforestation had contributed to habitat degradation in some areas on Perhentian Island. A study was conducted to determine the composition, diversity and aboveground biomass of the trees species at the coastal and inland forest of Perhentian Island, Terengganu. Three plots of 20 x 30 m were established on each inland and coastal forest of the island which altogether study plot was 0.36-hectare and all trees with the size of one cm diameter and above were recorded. Inland forest has higher individuals with 844 individuals representing 70 species from 48 genera and 30 families. A total of 367 individuals, representing 93 species from 71 genera and 30 families were recorded at the coastal forest. The Shannon-Weiner Diversity Index (*H*') was high in both forest plots with 3.20 (*H 'max* = 4.25) at the inland forest and 3.97 (*H' max* = 4.53) at the coastal forest. The Shannon Evenness Index (*E*') in the inland forest plots was 0.71 and 0.88 at coastal forest. The total above-ground biomass at the inland forest was higher than the coastal forest with 600.51 t/ha and 364.01 t/ha respectively. Seven tree species which considered endemic to East Coast Peninsular to Malaysia were found at Perhentian Island. Besides, a total of 23 species of 125 species recorded found were listed in the IUCN Red Data Book.

Keywords: Coastal forest, floristic variation, aboveground biomass, Perhentian Island, Peninsular Malaysia

INTRODUCTION

Perhentian Islands is a well-known tourism site for Terengganu, Malaysia since decades and it is located approximately 21 km from mainland Kuala Besut *E*etty which can be reached by 45 minutes boat ride. Perhentian Island comprised of two islands called as Perhentian Kecil and Perhentian Besar. Both islands were separated by a very narrow channel with strong water current. Perhentian Besar is the largest island within this archipelago and consists of many ridges with the highest peak reaching 321 meters above sea

level, separated by lowlying valleys (Turner et al., 2003). Perhentian Besar was covered with several plant species such as trees, climbers, palms and shrubs forming a dense forest floor and heavily covered canopy.

There are many impacts caused by tourism development especially on physical elements such as water supply, solid waste management, electricity supply, sewage management, hill erosion and water pollution based on studies carried out by Muhibudin & Mohamed (2014). Besides, the land clearance for resorts and chalet development chad contributed to the habitat destruction on Perhentian Island (Tan 2000). Based on Gazi et al., (2004) and Tamblyn *et al.,* (2005), there are several studies highlighted that the coral habitats have been destructed due to the expansion of tourism activities in Perhentian Islands. The wildlife in the forest also disturbed by noise and air pollution that derives from tourists activities such as open burning and use of motored vehicles (Masduki et. al, 2016). Moreover, the smuggling of endangered species would be the most feared damage to wildlife (Ibrahim & Ahmad, 2010). All these activities had brought attention from the state government and other government agencies in conserving this area.

Previous researches on tree species distribution and diversity on Malaysian Peninsular islands were collectively done at Tioman (Latiff et al., 1999), Langkawi (Rohaiza, 2011), Pangkor (Ghollasimood et al., 2011) and Redang (Khairil et al., 2012). Besides research on tree species diversity and composition at Pulau Perhentian had also been conducted recently by Pesiu et al., (2015) and Pardi et al., (2018). However, their studies cover a small plot which limited to the inland forest and focused on trees with a diameter of 5 cm and 10 diameters and above. According to Memiaghe et al. (2016), small-diameter tree population are also important to demographic rates and nutrient cycling, thus in this study, we sampled the trees with the size of 1cm diameter and above on this island. By this sampling, the important features of the tree species composition and structure on this island can be determined. The study conducted comprises two main objectives which are to determine the composition, diversity and abundance of tree species with the diameter size of 1 cm and above. Secondly, to assess the above-ground biomass and the status of endemism and conservation of the tree species on this island.

MATERIALS AND METHODS

Study site

The Perhentian Island Archipelago is located between 102°43'30" E to 102°45'30" E and 5°54'N to 5°54'30" N, approximately 21 km off Kuala Besut, Terengganu, Peninsular Malaysia (Figure 1 & 2). Pulau Perhentian is one of the thirteen gazetted islands in Terengganu and became one of the fabulous marine parks in Malaysia. The population of Perhentian Island is about 1,300 people with nearly 80% engaged in the tourism sector, 20% in the public sector and retail business (Anon 2015). Perhentian Island is experiencing monsoon season from November to March each year and it is closed from any events and visits to tourists during the monsoon

Statistical Analysis

Aboveground biomass of the trees was calculated following Kato et al. (1978) where the basal area (BA), tree height (H), the biomass of stems (*Ws*), branches (*Wb*) and leaves (*Wl*) by using the formula the tree diameter. Density, dominance, frequency, and Importance Value Index (*IVi*) were determined at species and family levels of species abundances following Brower *et al.,* (1997). The Species diversity was measured expending the Shannon-Weiner Index of Diversity (*H'*) Shannon Evenness Indices (*E'*) and Margalef Richness (*R'*) were also been calculated following Magurran (1988) and was made using Paleontological Statistics (PAST) Version 3.15 (Hammer et. al 2001).

RESULTS

Taxonomic composition

A total of 1211 trees of 125 species from 60 genera and 38 families from total of 0.36 ha plot were recorded. Inland forest plots consist 844 individuals of 70 species from 48 genera and 30 families while 367 individuals of 93 species from 59 genera and 30 families were recorded at coastal forest plots (Table 1 & Appendix). Myrtaceae had the highest density at the inland forest plot with 1656 ind/ha, while the highest density in coastal forest is Rubiaceae with 361 ind/ha. Based on species, *Syzygium cinereum* had the highest density at the inland forest with 1217 ind/ha followed by *Symplocos adenophylla* (733 ind/ha), *Rhodamnia cinerea Eack*, *Psydrax sp.* 10 and *Vatica cinerea* with 272 ind/ha, respectively.

Table 1: List of taxonomic composition in the two forest plots at Perhentian Islands, Terengganu.

	Inland plot			Coastal plot		
Family	**Genera**	**Species**	**Individual**	**Genera**	**Species**	**Individual**
Anacardiaceae	2	2	29	4	5	14
Annonaceae	nil	nil	nil	2	2	7
Aquifoliaceae	1	1	1	nil	nil	ni
Burseraceae	1	1	2	1	2	2
Calophyllaceae	1	3	6	1	1	2
Clusiaceae	1	4	55	1	6	56
Dipterocarpaceae	1	1	40	3	4	34
Ebenaceae	1	2	23	1	3	8
Elaeocarpaceae	1	5	24	1	2	9
Erythroxylaceae	nil	nil	nil	1	1	2
Euphorbiaceae	5	6	21	6	7	22
Fabaceae	1	1	1	2	3	9
Fagaceae	2	2	4	1	1	1
Hypericaceae	1	2	6	0	0	0
Ixonanthaceae	1	2	8	0	0	0
Lauraceae	1	2	4	2	3	6
Lecythidaceae	1	1	2	nil	nil	ni
Melastomataceae	1	1	2	1	1	2
Meliaceae	nil	nil	nil	1	1	3
Moraceae	1	1	2	2	2	9
Myristicaceae	3	3	3	1	3	16
Myrtaceae	2	9	298	2	9	38
Ochnaceae	2	2	13	nil	nil	ni
Oleaceae	1	1	4	nil	nil	ni
Peraceae	1	1	1	nil	nil	ni
Phyllanthaceae	1	2	2	1	1	5
Picrodendraceae	1	1	4	nil	nil	ni
Polygalaceae	nil	nil	nil	1	1	1
Portulacaceae	nil	nil	nil	1	1	1
Primulaceae	2	2	9	1	1	2
Rosaceae	nil	nil	nil	1	1	1
Rubiaceae	7	7	96	10	17	65
Sapindaceae	1	1	4	3	4	16
Sapotaceae	2	2	38	3	4	12
Simaroubaceae	1	1	10	1	1	10
Sterculiaceae	nil	nil	nil	2	3	7
Symplocaceae	1	1	132	1	2	6
Verbenaceae	nil	nil	nil	1	1	1

Table 2: Families and species with the highest density in the two forest plots at Perhentian Islands, Terengganu.

	Family	Ind/ha	Species	Ind/ha
Inland	**Myrtaceae**	1656	*Syzygium cinereum*	1216
	Symplocaceae	733	*Symplocos adenophylla*	733
	Rubiaceae	533	*Rhodamnia cinerea*	272
	Clusiaceae	306	*Psydrax sp.* 10	272
	Dipterocarpaceae	222	*Vatica cinerea*	222
Coastal	**Rubiaceae**	361	*Garcinia nigrolineata*	256
	Clusiaceae	311	*Vatica cinerea*	156
	Myrtaceae	211	*Syzygium pachyphyllum*	106
	Dipterocarpaceae	189	*Baccaurea parviflora*	61
	Euphorbiaceae	122	*Canthium horridum*	56

At the coastal plot, *Garcinia nigrolineata* also had the highest density with 256 ind/ha, followed by *Vatica cinerea* with 156 ind/ha, *Syzygium pachyphyllum* with 106 ind/ha, *Baccaurea parviflora* with 61 ind/ha and *Canthium horridum* with 56 ind/ha. The density of families and species at the two forest plots is shown in Table 2.

Forest Structure

In this study, *Vatica cinerea* (Dipterocarpaceae) was the most important species at the coastal forest with species importance value index (*SIVi*) of 12.43 % followed by *Syzygium pachyphyllum* (Myrtaceae) with 9.61 and *Garcinia nigrolineata* (Clusiaceae) with 9.05. At the inland forest, *Syzygium cinereum* (Myrtaceae) was the most important species with *SIVi of* 17.72 % followed by *Symplocos adenophylla* (Symplocaceae) and *Syzygium pachyphyllum* (Myrtaceae) with 10.59% and 7.03 % respectively. Besides, Rubiaceae was found to be the most important family at coastal forest plot with family importance value index (*FIVi*) of 16.3 % (Table 3). At the inland forest plot, Myrtaceae was recorded as the most important family with 28.96 % followed by Symplocaceae and Rubiaceae with 11.74 and 7.14 % respectively. According to Curtis & Marcintosh, (1951), when the species and family with *IVi* of more than 10% and 40% respectively, it can be considered categorical dominance in a particular area.

Species diversity and community similarity

Overall the Shannon-Weiner Diversity H' recorded from 0.36 ha plot in this study was 4.18 (*H'max* 4.82). Inland forest has lower value of *H'* with only 3.20 (*H' max* 4.25) compared to coastal forest with 3.97 (*H'max* 4.53). According to Magurran (1988), the value of *H'* usually lies between 1.5 and 3.5, while in exceptional cases, the value can exceed 4.5 and above. The value of Shannon Evenness Index (*E*') recorded in inland forest plot was 0.71 while coastal forest plot with 0.88. Referring to Magurran (1988), a *E'* value of 1.00 represents a situation in which all species are equally abundant. The Margalef Richness Index (*R*') revealed that the tree species richness in the inland forest is lower than coastal forest plot with 69.76 and 92.78 respectively indicating the coastal forest was highly diverse compared to inland. According to Brower et al. (1997), the richness can be expressed simply as the number of species. The comparison of the diversity, evenness and richness between this study and other islands is shown in Table 4.

Aboveground biomass

The total above-ground biomass of trees in the inland plot was higher than coastal forest plot with 600.51 tons/ha and 364.01 tons/ha respectively (Table 5). In terms of species aboveground biomass, *Syzygium pachyphyllum* has the largest aboveground biomass at the inland forest plot with 129.79 t/ha whereas *Mangifera pentandra* has the largest aboveground biomass at the coastal forest plot with 78.68 t/ha. Based on family, Myrtaceae has the largest above-ground biomass at the inland plots with 261.96 t/ha while Anarcadiaceae has the largest aboveground biomass with 89.60 t/ha at the coastal forest plot (Table 6). Based on the tree class size, trees with the size larger than 15 cm had higher aboveground biomass with 518.96 t/ha at inland forest plot and 340.94 t/ha at coastal forest plot. Whereas tree class size of 1.0 cm to 5.0 cm has the lowest aboveground biomass in both forest plots with inland forest plot had higher aboveground biomass (tons/ha) compared to coastal forest plot with 6.33 t/ha and 2.76 t/ha respectively (Table 7).

Table 3: Value of Importance (IV_i) of inland and coastal forest plots at Perhentian Island, Terengganu, Peninsular Malaysia

Location	Species (SIV_i)	Value (%)	Family (FIV_i)	Value (%)
Inland	***Syzygium cinereum* (Myrtaceae)**	17.72	Myrtaceae	28.96
	***Symplocos adenophylla* (Symplocaceae)**	10.59	Symplocaceae	11.42
	***Syzygium pachyphyllum* (Myrtaceae)**	7.03	Rubiaceae	7.14
Coastal	***Vatica cinerea* (Dipterocarpaceae)**	12.43	Rubiaceae	16.30
	***Syzygium pachyphyllum* (Myrtaceae)**	9.61	Myrtaceae	14.13
	***Garcinia nigrolineata* (Cuisaceae)**	9.05	Dipterocarpaceae	11.64

Table 4: Species diversity indices value at Perhentian Islands, Terengganu with a comparison of the other studies focusing on the Island.

Study	Location	Shannon-Weiner Diversity, *H'*	Shannon Evenness, *E'*	Margalef Richness, *R'*
Present study	**Inland**	3.20	0.71	69.76
	Coastal	3.97	0.88	93.1
Pardi *et al.*, (2018)	**Perhentian Islands**	3.94	0.85	na
Khairil *et al.*, (2012)	**Pulau Redang (Coastal)**	3.40	0.88	47.7
	Pulau Redang (Inland)	3.50	0.89	49.7
Ghollasimood *et al.*, (2011)	**Pulau Pangkor**	3.50	Na	na

*na: non-available

Table 5 :The comparison of above-ground biomass between this study with other studies in Peninsular Malaysia.

Study	Total aboveground biomass (tons/ha)	Tree individuals (ind/ha)
This study (Coastal)	364.01	367
This study (Inland)	600.51	844
Khairil *et al.*, 2012		
Redang Islands (Coastal)	491	167
Redang Islands (Inland)	408	220
Khairil *et al.*, 2011		
Inland	366	2061
Seasonal Flood	379	1019
Riverine	401	894
Ismail *et al.*, 2009	399	399
Rohaiza Daud, 2011		
Pulau Singa Besar	874	874
Pulau Timun	575	575
Raffae, 2003		
Bukit Matchincang	527	527
Foo, 2005		
Riverine	284	284
Inland	205	205

Table 6: The five highest above-ground biomass (tons/ha) of species and families at the two forest plots at Perhentian Islands

Plot	Species	(tons/ha)	Family	(tons/ha)
Inland	*Syzygium pachyphyllum* (Myrtaceae)	129.79	Myrtaceae	261.96
	Syzygium cinereum (Myrtaceae)	112.02	Sapotaceae	81.62
	Palaquium obovatum (Sapotaceae)	81.61	Symplocaceae	63.72
	Symplocos adenophylla (Symplocaceae)	63.72	Dipterocarpaceae	46.06
	Vatica cinerea (Dipterocarpaceae)	46.06	Clusiaceae	42.38
Coastal	*Mangifera pentandra* (Anacardiaceae)	78.68	Anacardiaceae	89.60
	Syzygium pachyphyllum (Myrtaceae)	71.32	Myrtaceae	84.08
	Pouteria obovata (Sapotaceae)	45.13	Sapotaceae	68.89
	Vatica cinerea (Dipterocarpaceae)	28.81	Dipterocarpaceae	34.94
	Palaquium obovatum (Sapotaceae)	22.38	Moraceae	19.98

Table 7: The aboveground biomass (t/ha) of trees based on the class size

Size class (dbh) cm	Inland			Coastal		
	Ind	Ind/ha	t/ha	Ind	Ind/ha	t/ha
1.0 - 4.99	520	2889	6.33	257	1427	2.76
5.0 - 9.99	159	883	30.51	51	283	7.90
10.00 – 14.99	75	433	44.72	18	100	12.41
>15.0	80	444	518.96	41	227	340.94
Total	844	4688	600.51	367	2037	364.01

Table 8: List of endemic species to East Coast Peninsular Malaysia which are found at Perhentian Island

Family	Species	Location
Calophyllaceae	*Calophyllum rotundifolium* Ridl	Ph
Elaeocarpaceae	*Elaeocarpus knuthii* ssp. *cuspidatus* (Ridl.) Coode	Ph
Clusiaceae	*Garcinia clusiifolia* Ridl	Ph
Dipterocarpaceae	*Hopea odorata* Roxb	Tg, Kl, Kd
Sapotaceae	*Madhuca sericea* (Miq.) H.*E*. Lam var. *ridleyi* Ng	Ph, Tg
Rubiaceae	*Morinda calciphila* K.M. Wong	Kl, Kd, Pk
Myrtaceae	*Syzygium zeylanicum* (L) DC.	Kd, Tg

*Notes: Tg = Terengganu; Kl = Kelantan; Ph = Pahang; Kd = Kedah; Pk = Perak

Table 9: The conservation status of tree species at Perhentian Islands based on IUCN Red Data List 2019

Family	Species	Conservation status
Anacardiaceae	*Mangifera pentandra*	Data Deficient
Burseraceae	*Dacryodes rugosa*	Least Concern
Calophyllaceae	*Calophyllum tetrapterum*	Least Concern
Dipterocarpaceae	*Vatica cinerea*	Data Deficient
Dipterocarpaceae	*Hopea odorata*	Vulnerable
Dipterocarpaceae	*Vatica pauciflora*	Vulnerable
Ebenaceae	*Diospyros pyrrhocarpa*	Least Concern
Elaeocarpaceae	*Elaeocarpus petiolatus*	Least Concern
Fabaceae	*Sindora wallichii*	Least Concern
Hypericaceae	*Cratoxylum arborescens*	Least Concern
Hypericaceae	*Cratoxylum formosum*	Least Concern
Meliaceae	*Aglaia odoratissima*	Least concern/ vulnerable
Myristicaceae	*Knema globularia*	Least Concern
Myristicaceae	*Knema malayana*	Least Concern
Myristicaceae	*Myristica iners*	Least Concern
Myrtaceae	*Rhodamnia cinerea*	Least Concern
Ochnaceae	*Brackenridgea hookeri*	Least Concern
Phyllanthaceae	*Antidesma leucopodum*	Least Concern
Rosaceae	*Prunus arborea* var. arborea	Least Concern
Rubiaceae	*Ixora Eavanica* var. *E*avanica	Least Concern
Sapindaceae	*Palaquium obovatum*	Least Concern
Sterculiaceae	*Scaphium macropodum*	Least Concern
Verbenaceae	*Vitex pinnata*	Least Concern

Table 10: Number of tree species in this study with comparison of the other studies on Peninsular Islands, Malaysia.

Study	Location	Number of species
Present study	Perhentian Islands (0.36 ha)	125
Pardi *et al.*, (2018)	Perhentian Island (0.35 ha)	102
Pesiu *et al.*, (2015)	Perhentian Island (0.25 ha)	52
Khairil *et al.*, (2012)	Redang Island	72
Senterre *et al.*, (2005)	Pulau Babi Tengah	77
Rohaiza (2011)	Pulau Singa Besar (0.5 ha)	84
	Pulau Timun Langkawi (0.5 ha)	75
Raffae (2003)	Gunung Matchincang Forest Reserve , Langkawi (2.6 ha)	117

Figure 1: The location of Perhentian Island, Terengganu, Peninsular Malaysia indicated by red circle. The image was provided by the Geographical Centre, Universiti Kebangsaan Malaysia (UKM).

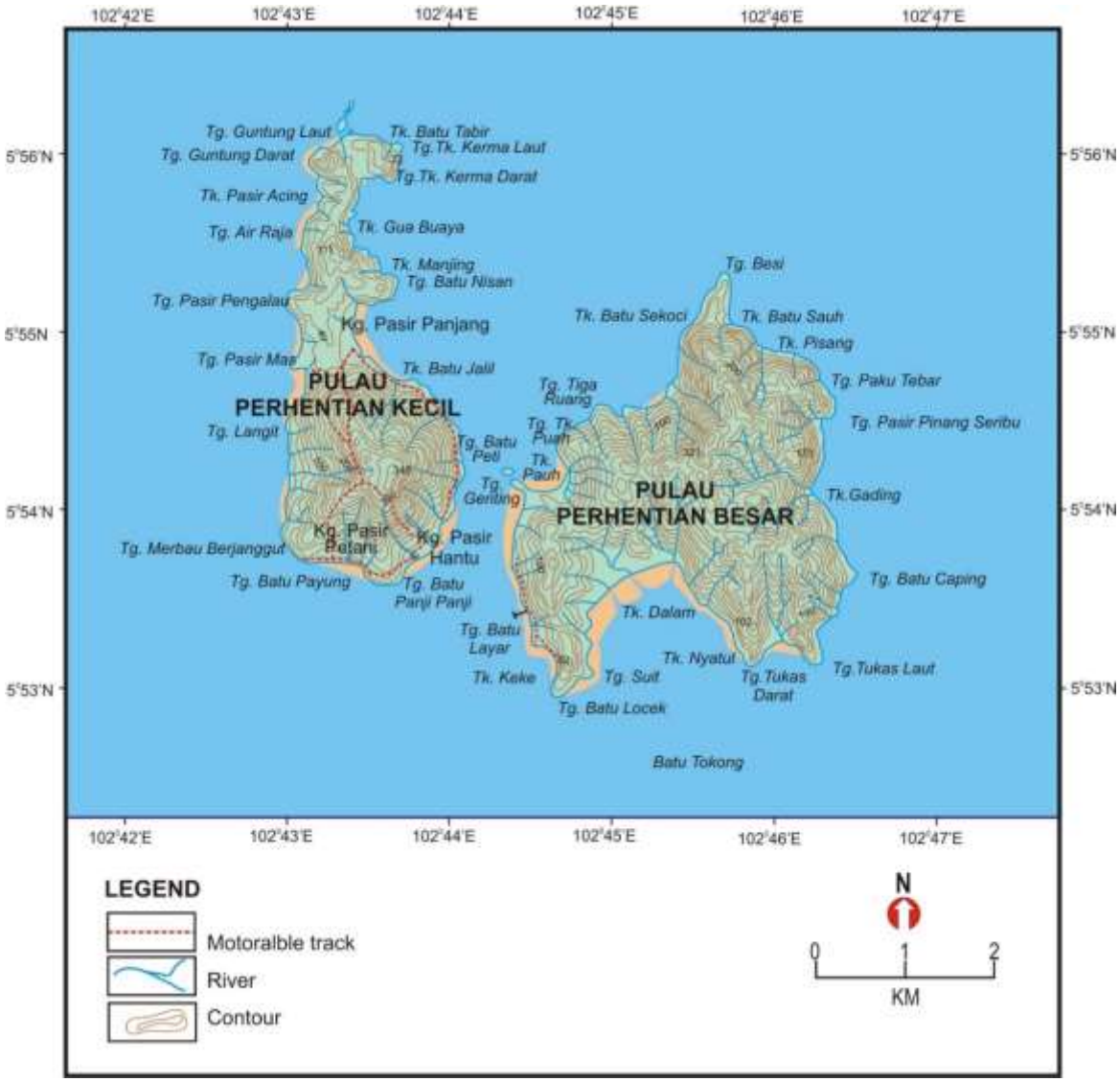

Figure 2: The location of the study sites at coastal forest indicated by blue star and inland forest indicated by the red square. The image was provided by the Geographical Centre, Universiti Kebangsaan Malaysia (UKM).

Endemism and conservation status

According to Ng *et al.,* 1991, the number of endemic tree species in Peninsular Malaysia is 746 which represent 26.4% of the total number of species (2830 species). Seven species from seven families were identified as endemic species to East Coast Peninsular Malaysia can be found in this study which equals to 6% from the total 125 species recorded in this study (Table 8). A total of 23 (18.4%) species from 125 species recorded in this study were listed in the IUCN Red List Categories of World Conservation Monitoring Centre (WCMC) 2019 (IUCN, 2019). These species were rated in three different threat categories, for instance, least concern, vulnerable and data deficient. Based on Table 9, a total of 20 species were listed as least concern, two species vulnerable and another two species as data deficient. Nevertheless, *Vatica cinerea* and *Mangifera petandra* were listed as data deficient.

DISCUSSION

Taxonomic composition

Overall, the number of species recorded in this study was considered higher than other

previous studies on the islands at Peninsular Malaysia (Table 10). A study conducted by Pardi et al (2018) only found, 702 individuals with 102 species from 65 genera and 28 families. The species number observed in this study was also higher compared to Pesiu et al. (2015) where they only recorded 52 species from 40 genera and 29 families, while at Bidong Island, a total of 102 tree species were recorded which consisted of 66 genera and 37 families. At Redang Island coastal forest, 167 individuals representing 48 species from 37 genera and 26 families were recorded and Shorea glauca (Dipterocarpaceae) were the most important species at the coastal forest (Khairil et al., 2012).

Previous studies at Perhentian Island by Pesiu et al., (2015), found that the most abundant families were Dipterocarpaceae with Shorea leprosula was the most abundant species, followed by the family of Myrtaceae and Anacardiaceae. These families were also been recorded as among the dominant families recorded in many island-based studies in Peninsular Malaysia by Rohaiza, 2011 (Langkawi); Khairil et al., 2012 (Redang Island); Raffae, 2013 (Bukit Matchincang) and Ghollasimood et al., 2011 (Pangkor Island). A recent study by Pardi et al., (2018) also found Rubiaceae was the most abundance family followed by Ebenaceae and Guttiferae at Perhentian Islands. Similar result also was reported by Ghollasimood et al. (2011) which Rubiaceae was the most abundance family at a coastal hill forest in Pangkor Island. Rubiaceae is reported as one of the five most species-rich flowering plant families, and it is not surprising because this family is widely distributed in tropical region (Whitmore 1984; Manokaran et al., 1990).

Forest Structure

Vatica Cinerea (Dipterocarpaceae) was the most important species at the coastal forest with species importance value index (SIVi) of 12.43 % whereas Syzygium cinereum (Myrtaceae) was the most important species at the inland forest plot with SIVi of 17.72 %. In terms of family importance value index (FIVi) Rubiaceae was found to be the most important family at coastal forest plot with 16.3 % whereas Myrtaceae at the inland forest plot with 28.96 %. Compared to previous studies on island-based of Redang Island (Khairil et al., 2012), the most important species at the coastal plots was Shorea glauca (Dipterocarpaceae) with SIVi of 10.5 % and Dipterocarpaceae was found to be the most important family at Redang island with FIVi at 20.4 %. In addition, Pardi et al. (2018) reported, Shorea leprosula was the most important species in their study at Perhentian Islands with *SIVi* of 8.45% and Dipterocarpaceae was recorded as an important family with FIVi of 24.54%. Besides, the result observed in this study are also different from those of Raffae (2003), Nurhashimah (2008) and Khairil et al. (2011; 2014) who reported that Euphorbiaceae was the most important family at their study sites. According to Curtis and Macintosh (1951), species with an SIVi of more than 10 % and families with a FIVi of more than 40 % can be considered dominant species or families in a particular community. Therefore, in this study, Vatica Cinerea and Syzygium cinereum were clearly dominating the forests at the coastal and inland sites of Perhentian Island. However, there was no dominant family identified in these two forest types.

Species diversity and similarity

The Shannon-Weiner Diversity index (*H*') at the inland forest was 3.20 (H' max 4.25) and was lower than the coastal forest with 3.97 (H'max 4.53) (Table 4). Overall the The Shannon-Weiner Diversity index in this study was 4.18 (H'max 4.98). The H' value recorded in this study is considered higher compared to a recent study at Perhentian Island (Pardi et al. 2018) with H' value of 3.9, Redang Island (Khairil et al., 2012) with H' of 3.4 and Pulau Timun and Pulau Singa Besar, Langkawi Island (Rohaiza, 2011) with H' values of 3.9 and 3.6. The value however is slightly lower compared to other studies such Bukit Matchinchang, Langkawi (Raffae, 2003) with H' value of 4.32, Ismail et al. (2009) at compartment 156 Pekan Forest Reserve with H' value of 4.2 and Khairil et al. (2011) at Chini watershed with H' 5.4. This may be because our study was carried out on a relatively small island compared to mainland sites where the diversity was relatively higher.

The value of Shannon Evenness Index (*E'*) recorded in inland forest plot was 0.71 while coastal forest plot with 0.88. The value in this study was slightly lower compared to other studies in Perhentian Island previously by Pardi et al. (2018) which were 0.85 and a study at Pulau Redang by Khairil et al. (2011) with the value of 0.89. Based on the Shannon Evenness Index (*E'*), the two forest types have similar values, i.e. 0.88 versus 0.89. Referring to Magurran (1988), a *E'* value of 1.00 represents a situation in which all species are equally abundant.

Endemism and Conservation Status

Seven tree species which eaqual to 6% from the 125 species recorded were endemic to East Coast Peninsular Malaysia. This value is slightly lower to a study conducted by Khairil et al., (2012) at Redang Island where they found 8.3% from 72 species recorded were endemic to East Peninsular Malaysia. Furthermore, this study recorded 20 species of 125 species listed in the IUCN Red Data List (2019) and indicated a higher number of threatened species than other previous studies. The result observed is slightly higher than a recent study by Pardi et al. (2018) where a total of 17 species out of 102 species rcorded (16.7%) were found at their study plot. Nevertheless, study conducted in Redang Island by Khairil et al., (2012), only found 11 species (11.1 %) which were listed in the IUCN Red Data Book. The higher number recorded in this study may be due to the sampling method where we sampled the trees with the size of 1cm diameter and above besides larger sampling plot.

Aboveground biomass

In this study, the result showed the inland forest plot has higher total aboveground biomass compared to coastal forest plot with 600.51 tons/ha and 364.01 tons/ha respectively (Table 5). Total aboveground biomass at inland forest plot in this study is considered higher compared to few studies conducted at the inland forest such as at Bukit Panchor, Penang Island (Norazlinda et al., 2016), Chini watershed (Khairil et al., 2011), Pekan Forest Reserve (Ismail et al., 2009), Bukit Matchinchang (Raffae, 2003) and Kenong Forest Park, Pahang (Foo, 2005). From the results and comparison with other previous study, it is shown that the total aboveground biomass in the inland forest at Perhentian Island was higher compared to other study (Table 6). The factors such as the number of individuals, forest gaps and tree size may contribute to the higher aboveground biomass in the inland forest plot (Norwahidah, 2005; Rohani, 2008; Khairil et al., 2011).

CONCLUSION

The two types of forest at Perhentian Island showed different floristic patterns and this study proofed that Perhentian Island had a high diversity and density of the tree species. Habitat degradation contributed by the tourism activities may affected the diversity of tree species on this island. Based on the number and individuals of endemic and threatened species, a proper management and conservation strategy for this area is important to make the tourism industry sustainable. Further research on the physicochemical of the soil at this area is needed to investigate the factors which may controlling the distribution and abundance of tree species at this area. Knowledge on these association will be useful in conserving the habitat at Perhentian Island. Nonetheless, the database on the tree species in this study will be useful for stakeholders and government agencies to increase the effort on conserving and managing this island in the future

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

M. Khairil, A. Noor Ain, M. Salmah, A. Nur Fara Nazuha, A. Nur Azalina, A, & M. S Razali involved in the tree species sampling. I. Azimah and R. Noor-Amalina involved in data and statistical analyses. M. Khairil, A. Noor Ain, K. Moneruzzaman and Y. Nornasuha involved in the manuscript writing and M. Khairil is the project leader. All authors read and approved the final version.

REFERENCES

Anon, A. (2015). Perhentian Island, Pulau Perhentian, Perhentian Kecil & Besar, Kuala Besut, Terengganu, Malaysia. Marine Park Department, Malaysia.

Brower *E*e, H Herold, H Zar And C Van Ende (1997). *Field and Laboratory Wetlands for General Ecology*. Mc Graw-Hill Companies, Inc. USA.

Curtis *E*t & Macintosh Rp (1951). An upland

continuum in the prairie-forest border region of Wisconsin. Ecology, 32: 476-496.

Foo. WS 2005. Comparative Studies on Tree Species Composition, Diversity and Above Ground Biomass at Riparian and Inland Forest, Kenong Forest Park, Pahang. Master of Science Thesis, National University of Malaysia (unpublished).

Gazi M. I., Tai S.Y., Kusairi M. N., Aswani Farhana M.N. (2004). Community's Perspectives towards Marine Protected Area in Perhentian Marine Park, Malaysia. Open *E*ournal of Marine Science, 4: 51-60.

Ghollasimood S, Faridah-Hanum I, Nazre M & Karnziah AK (2011). Tree species composition and structure of a coastal hill for-est in Pulau Pangkor, Malaysia. *E*ournal of Agricultural Science 3(4),172-187.

Hammer, Ø., Harper, D.A.T., And P. D. Ryan, 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1): 9 pp.

Hamzah, A., & Hampton, M. P. (2011). Tourism development and change in small islands: Lessons from Perhentian Kecil, Malaysia. Skudai, Malaysia: Centre for Innovative Planning and Development, Universiti Teknologi Malaysia.

Ibrahim E.A, Ahmad M.Z. (2010). Penubuhan Geotaman Langkawi: Kesan Kepada Pelancongan Langkawi, 1–12.

Islam, G. M. N., Noh, K. M., Yew, T. S., & Noh, A. F. M. (2013). Assessing Environmental Damage to Marine Protected Area: A Case of Perhentian Marine Park in Malaysia. *Eournal of Agricultural Science*, *5*(8), 132–141.

Ismail P, Nizam Ms, I Faridah-Hanum, H Khali Aziz, I Shamsudin, M Shamsudin And A Latiff (2009). Community structure, diversity and biomass of trees in two forest subtypes of Pekan Forest Reserve, Pahang, Malaysia. *The Malaysian Forester*; 72, 117-33.

IUCN (2019). *The IUCN Red List of Threatened Species. Version 2019-2*. http://www.iucnredlist.org. Accessed March 2019.

Jaafar, M. And Maideen, S.A. (2012). Ecotourism-related products and activities, and the economic sustainability of small and medium island chalets. Tourism Management: 33, 683-691.

Kato, R., Tadaki, Y., Ogawa, H. (1978). Plant biomass and growth increment studies in Pasoh Forest. Malay. *Nat. E* (30), 211–224.

Khairil M, Nashriyah M, Norhayati N, Shahril A, & Nur Fatihah (2012), Tree Species Composition, Diversity and above Ground Biomass of Two Forest Types at Redang Island, Peninsula Malaysia. *Walailak Eournal of Science and Technology* 10(1): 77-90.

Khairil, M., Wan *E*uliana, W.A., Nizam, M.S. & Faszly, R. (2011). Community Structure And Biomass Of Tree Species At Chini. *Sains Malaysiana*, 40(11), 1209-1221.

Latiff, A. And Faridah-Hanum, I. (2006). Gunung Mandi Angin Terengganu, Pengurusan, Persekitaran Fizikal, Kepelbagaian Biologi Dan Pelancongan Ekologi. Jabatan Perhutanan Semenan*E*ung Malaysia. 53-54.

Latiff, A., Hanun, I.F., Ibrahim, A.Z., Goh, N.W.K., Loo, A.H.B. And Tan, H.T.W. (1999). On the vegetation and flora of Pulau Tioman, Peninsular Malaysia. *The Raffles Bulletin of Zoology.* 6: 11–72.

Magurran AE (1988). *Ecological Diversity and its Measurement*. Chapman and Hall, London.

Manokaran N, La Frankie EV, Kochummen KM, Quah ES, Klahn E, Ashton Ps & Hubbell SP (1990), Methodology for the fifty hectare research plot at Pasoh Forest Reserve. Research Pamphlet No. 104, Forest Research Institute of Malaysia (FRIM), Kuala Lumpur p. 69.

Memiaghe1, H.R. , *E*ames A. L., Lisa K, Alfonso A., David K., 2016. Ecological Importance of Small-Diameter Trees to the Structure, Diversity and Biomass of a Tropical Evergreen Forest at Rabi, Gabon. *Plos One* 11(5): e0154988.

Muhibudin & Mohamed (2014), Manokaran N, La Frankie *E*v, Kochummen KM, Quah ES, Klahn E, Ashton PS & Hubbell SP (1990), Methodology for the fifty hectare research plot at Pasoh Forest Reserve. Research Pamphlet No. 104, Forest Research Institute of Malaysia (FRIM), Kuala Lumpur p. 69.

Ng FSP (ed.) (1978). *Tree Flora of Malaya*. A manual for foresters, Vol. 3. Longman Malaysia Sdn. Bhd. Kuala Lumpur, p.339.

Ng FSP (ed.) (1989). *Tree Flora of Malaya*. A manual for foresters, Vol. 4. Longman Malaysia Sdn. Bhd. Kuala Lumpur, p. 549.

Ng FSP, Cm Low AND NS Mat Asri (1991). *Endemic Tree of Malay Peninsula*. Research Pamphlet, FRIM Kepong, Kuala Lumpur, 1991.

Ngai Weng, C., (2009). Ecotourism and environmental conservation in small islands

in the East Coast of Peninsular Malaysia. *Malaysian Eournal of Environmental Management,* 2 : 53-69.

Norazlinda, M., Nizam, M. S., Latiff, A., Ahmad Fitri, Z. & Sani, M. (2016). Tree Species Composition, Diversity and Biomass of Bukit Panchor State Park, Pulau Pinang, Malaysia. The 2016 UKM FST Postgraduate Colloquium AIP Conf. Proc. 1784, 060028-1–060028-5.

Norwahidah ZA 2005. Comparative Study of Tree Species Composition, Diversity and Biomass of Riparian Forest and Ad*E*acent Inland Forest at Tasik Chini, Pahang. Master Degree Thesis, National University of Malaysia, Malaysia (unpublished).

Pardi F, M N Mohd Said , A Ismail , N E Sidik , K A Radzun , H N Ruziman & S S Kasri (2018). Tree Diversity, Stand Structure, and Community Composition in an Island Forest of Pulau Perhentian Besar, Terengganu. *International Eournal of Engineering & Technology,* 7 (4). pp 31-35.

Pesiu, E., Abdullah, M. T., Reuben, C., Jamilah, S., & Muhammad Razali, S (2015). *Sustainable Tourism Botany in Pulau Perhentian*. Paper presented at the 2nd Langkawi International Conference on Adventure and ecotourism, Langkawi, Malaysia.

Raffae A (2003), Tree Species Diversity, Biomass and Economic Value of 2.6 ha Plot in Langkawi Island. Master Degree Thesis, National University of Malaysia (unpublished).

Rohaiza D (2011). The Diversity and Community Structure of Tree Species at Pulau Timun and Pulau Singa Besar Reserve Forest, Langkawi Island. Master Degree Thesis. National University of Malaysia (unpublished).

Rohani Shamsudin. (2008). Struktur komuniti, variasi flora dan bio*E*isim pokok di Taman Rimba Kenong, Kuala Lipis, Pahang. MSc. Thesis. Universiti Kebangsaan Malaysia (unpublished).

Salmond, *E*acqueline L. (2010). The Social Relations of Tourism on The Perhentian Islands. University of Kentucky Doctoral Dissertations. USA.

SENTERRE, B., CHEW, M. Y., & CHUNG, R. C. K. (2015). Flora and Vegetation of Pulau Babi Tengah, *E*ohor, Peninsular Malaysia. Check List: 11(4), 1714.

Tamblyn, A., Turner, C., O'malley, R., Weaver, N., Hughes, T., Hardingham, S., & Roberts, H. (2005). *Malaysia Tropical Forest Conservation ProEect, Report of the Perhentian Island*, Coral Cay Conservation Ltd. London, SW19 2*E*G, UK.

Tan, W.H. (2000). Guest-host interactions in Perhentian Islands. Teh, T.S. (ed.). Islands in Malaysia: Issues and challenges, 171-184

Turner, I.M. 1995. A catalogue of the vascular plants of Malaya. *Gardens' Bulletin, Singapore.* 7(1–2): 1–757.

United Nations Development Programme, UNDP. (2017). Mainstreaming of Biodiversity Conservation into River Management, 263.

Whitmore TC (ed.) (1972), *Tree Flora of Malaya*. Vol. 1, Malayan Forest Records No. 26. Longman Malaysia Sdn. Bhd., Kuala Lumpur.

Whitmore TC (ed.) (1973), *Tree Flora of Malaya*. Vol. 2, Malayan Forest Records No. 26. Longman Malaysia Sdn. Bhd., Kuala Lumpur .

Yap, S.Y. And Kahoru, T. (2001). A baseline study on water resources of the tourist island, Pulau Perhentian, Peninsular Malaysia from an ecological perspective. *The Environmentalist*: *21*: 273– 283.