



Species Diversity, Dominance and Management of *Shorea lumutensis*-Stand at Pangkor Island, Perak, Malaysia

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ABSTRACT

High Conservation Value Forest (HCVF) stand of *Shorea lumutensis*, one of the endemic dipterocarps in Peninsular Malaysia, was established in Pangkor Island, Perak, Malaysia to conserve the species. The study was carried out at the HCVF stand to identify species dominance and social behaviour of *S. lumutensis* for future ex-situ rehabilitation effort. A total of six (6) sample plots (in the size of 50 x 50m each) were prepared. The richness, heterogeneity and evenness analyses by the principle component analysis were carried out on five canopy layers such as emergent or super tree (ST), dominant (T1), co-dominant and suppressed (T2), shrub (S) and herb (H). The H-layer showed higher richness for Plot 1 (P1), P2 and P3, with 69.141, 65.178 and 83.135, respectively, and a high level of heterogeneity. Meanwhile, the ST-layer recorded the lowest values for richness, evenness and heterogeneity. No single species dominates the S, T2 and T1 layers. The S layer in P3 and P5 is dominated by *Diospyros subrhomboidea* and *Aporosa frutescens*, respectively, while *Fordia unifoliata*, *Vatica pauciflora*, *Teijsmanniodendron coriaceum* are dominant in P6. On the other hand, the T1 layer (Plot 3) is dominated by *Shorea maxwelliana*, *Vatica pauciflora* and *Hopea latifolia*. Only two individuals of *S. lumutensis* are found in the T1-ST layers of all plots, showing the lesser dominance of the species. Hence, it is suggested that bigger HCVF area is needed to protect the species.

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INTRODUCTION

Every forest has some biological, environmental and social values, and the values may include rare species, special

recreational sites or resources harvested by the local residents, of which can be considered as highly invaluable for them to be conserved. In the beginning, High Conservation Value Forest (HCVF) concept was developed by the Forest Stewardship Council (FSC) for utilization in forest management certification and published in 1999. Globally, HCVF is defined by FSC as a forest of outstanding and critical importance due to its high environmental, socio-economic, biodiversity or landscape values (Jennings *et al.*, 2003). In the Malaysian context, any forest containing endemic species as identified by Forest Research Institute Malaysia, Malaysian Nature Society, Sarawak Forest Corporation, Forestry Departments (Peninsular Malaysia, Sarawak and Sabah) and published literature, particularly in high concentrations or highly restricted distribution, can be considered as HCVF (WWF-Malaysia, 2009). Under Principle 9 of the FSC certification, forest managers are required to identify any High Conservation Values (HCVs), which occur within their individual forest management units to manage and to maintain them or to enhance the values identified, as well as to monitor the success of this management (Jennings *et al.*, 2003).

Endemic species are ones that are confined to a particular geographic area. When this area is restricted, then a species has particular importance for conservation. This is because restricted range increases the vulnerability of species to further loss of habitat (Jennings *et al.*, 2003).

In Southeast Asia, family Dipterocarpaceae, which hosts a huge array of biodiversity, is comprised of 155 species (Ashton, 1982), and Peninsular Malaysia is a home of those species, of which thirty (30) species are endemic to Peninsular Malaysia, with 12 being considered as rare (Boshier, 2011). One of the rarest and endemic dipterocarps in Peninsular Malaysia is *Shorea lumutensis*, which has been assigned as critically endangered (IUCN criteria: CRA1cd, C2a) due to suspected population reduction of at least 80% over the last 10 years and the population estimated to number less than 250 mature individuals (Boshier, 2011; IUCN, 2004). In HCVF, one of the key elements is endemic species conservation. Therefore, the objective of this research was to identify species dominance and the social behaviour of the *S. lumutensis* within the HCVF stand for future conservation and ex-situ rehabilitation efforts.

MATERIALS AND METHOD

The study was conducted at High Conservation Value Forest of *S. lumutensis* (Balau putih) at compartments 2 and 5 of Sungai Pinang Forest Reserve, Pangkor Island, in Perak (see Fig.1). A total of six (6) phytosociological relevés or sample plots (in the size of 50 x 50m each) were randomly prepared in the both compartments in 2008 (within the 10-ha HCVF stand). The sampling technique could be simply characterized as: a) Selection of homogenous sites without gaps within the compartment; b) Creation of sample plots

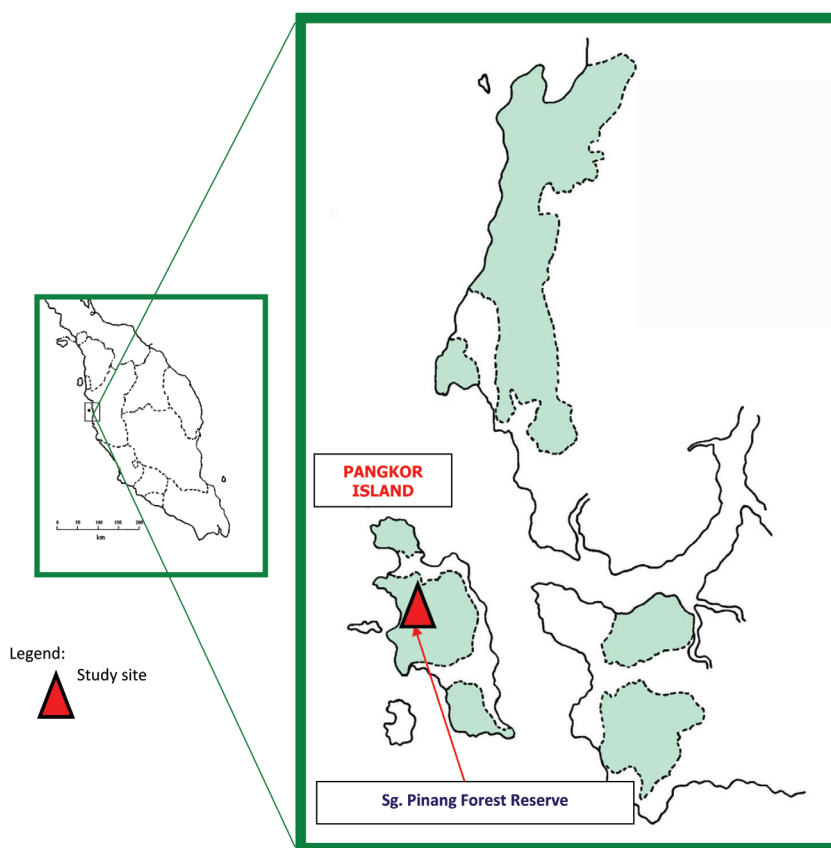


Fig. 1: Location of the study site at Sungai Pinang Forest Reserve, Pangkor Island (Adapted from Lee *et al.*, 2004)

with homogenous species composition; c) Identification and record of all species found in each of the five layers: emergent or super tree (ST: above 30m in total height), dominant (T1: 15–30m), co-dominant and suppressed (T2: 8–15m), shrub (S: 2–8m) and herb (H: lower than 2m); d) Estimation of canopy coverage and sociability, and e) Identification of communities. This sampling technique follows the phytosociological technique, which has been described by other researcher (Suzuki, 2005).

The diversity analysis (richness, heterogeneity and evenness) based on five

canopy layers, i.e. emergent or super tree (ST: above 30m in total height), dominant (T1: 15–30m), co-dominant and suppressed (T2: 8–15m), shrub (S: 2–8m) and herb (H: lower than 2m) was carried out by using the principle component analysis (PCA).

RESULT AND DISCUSSION

Species Diversity

Species diversity usually refers to the species richness, abundance, or a combination of both, of a community (Rice & Westoby, 1982). Looking at the H-layer alone, three

TABLE 1
Species diversity on five canopy layers

Layer	Diversity Parameters	Site					
		P1	P2	P3	P4	P5	P6
H	Number Individual	120	103	134	36	7	43
	Richness	69.141	65.178	83.135	32.319	7.751	37.282
	Heterogeneity	4.014	3.970	4.292	3.429	1.946	3.568
	Evenness	0.803	0.815	0.881	0.964	1.000	0.958
S	Number Individual	22	11	74	8	25	51
	Richness	11.815	8.763	31.480	6.775	14.641	26.565
	Heterogeneity	2.237	2.020	3.124	1.667	2.393	3.016
	Evenness	0.851	0.942	0.734	0.883	0.782	0.785
T2	Number Individual	29	28	78	22	43	57
	Richness	19.542	9.806	36.480	12.742	22.613	24.613
	Heterogeneity	2.737	1.739	3.362	2.284	2.892	2.941
	Evenness	0.813	0.632	0.802	0.818	0.820	0.789
T1	Number Individual	39	13	79	21	35	54
	Richness	21.613	9.723	30.500	15.653	22.537	25.588
	Heterogeneity	2.862	2.098	2.963	2.624	2.939	2.976
	Evenness	0.833	0.906	0.645	0.919	0.859	0.785
ST	Number Individual	10	5	7	3	4	10
	Richness	6.885	3.898	5.813	3.880	4.837	8.751
	Heterogeneity	1.696	0.950	1.550	1.099	1.386	1.973
	Evenness	0.908	0.862	0.942	1.000	1.000	0.899

Note: H = Herb (lower than 2m in height), S = Shrub (2-8m), T2 = Co-dominant and Suppressed (8-15m), T1 = Dominant (15-30m), ST = Emergent (more than 30m)

plots showed high species richness, namely; Plot 3 (P3) (with the species richness value of 83.14), followed by P1 (69.14), and P2 (65.18), whereas P5 exhibited the lowest level of species richness at 7.75 (Table 1). Generally, the distribution of individuals in all the plots is relatively uniform with the evenness value of less than 0.8.

Plot 3 (P3) attained the highest value of species richness at the S-layer, with a total value of 31.48 species, followed by P6 (26.57 species), and the lowest species richness was found in P4 at 6.78 species (Table 1). The plots showed high

individual distribution with heterogeneity of more than one (1) (see Table 1). Unlike the H-layer, only three plots, namely P3, P5 and P6 exhibited an evenness index of less than 0.8, of which P3 is dominated by *Diospyros subrhomboides*, while P5 is dominated by *Aporosa frutescens*, and P6 with *Fordia unifoliata*, *Vatica pauciflora* and *Teijsmanniodendron coriaceum*. The existences of heterogeneity, as shown in present study (of more than 1), have strong effect on species diversity (Whitmore, 1998).

Similar to the S-layer, P3 still showed the highest species richness of 36.48 species in T2-layer. The species distribution at P3 and P6 are lower than the other plots because of species domination, where P3 is dominated by *Fordia unifoliata*, and P6 is dominated by *Aporosa frutescens*, *Teijsmanniodendron coriaceum* and *Xanthophyllum affine*. The results are in agreement with the findings of Denslow (1995) and Preston (1962), where species richness was found to be positively associated with species abundance.

The highest species richness in the T1-layer was found at P3 with 30.50 species. Meanwhile, the heterogeneity of all the plots is higher than that of the other layers (H, S, and T2), with the value of more than two (2) and it showed that the total individual at all the plots was relatively high. *Shorea maxwelliana*, *Vatica pauciflora* and *Hopea latifolia* dominate P3, while P6 is dominated by *Swintonia floribunda*. The level of evenness at P3 and P6 is lower than the other plots (<0.8), indicating lower species domination, which is in agreement with the earlier findings by Magurran (2004) and Kindt *et al.* (2006), whereby the level of evenness is strongly influenced by the relative frequencies of species dominance.

The species richness of the ST-layer is generally lower (3.88 to 8.75) than the other layers (7.75 to 69.14), but its evenness value is relatively high, i.e., from 0.862 to 1.00, which is comparable to the other layers. According to He and Legendre (2002), species richness decreases with the increase in species dominance. Being the highest layer (biggest diameter class),

it was expected that this layer would have the least number of individuals (from 3 to 10) and also species, as shown in a typical inverse-J curve.

Domination Species Based on PCA

The spatial distribution of understorey vegetation may provide a clue to the nature, degree and duration of processes or resources that structure understorey communities and also assist in formulating hypotheses about the relevant processes (Dale, 1999). The H-layer is divided by two components; the first component consists P1, P2 and P5, whereas the second component is composed of P3, P4 and P6 (see Fig.2). Based on species similarity, the first component consists *Shorea maxwelliana* (5 individual/plot), *Swintonia floribunda* (1 individual/plot) and *Xanthophyllum affine* (3 individual/plot), whereas component two has *Diospyros subrhomboidea* (1 individual/plot), *Galearia fulva* (1.67 individual/plot), *Garcinia forbesii* (1.67 individual/plot), *Gynotroches axillaris* (1 individual/plot) and *Lijndenia laurina* (1.33 individual/plot).

Just like the H-layer, the S layer is also divided by two components; component 1 consists of P1, P2, and P5, whereas component 2 is made of P3 and P4, and P6 is located between components 1 and 2 (Fig.3). The main species in component 1 are *Aporosa frutescens* (5.67 individual/plot), *Mesua daphnifolia* (2.33 individual/plot) and *Xanthophyllum affine* (2.00 individual/plot), whereas *Diospyros subrhomboidea* (4.67 individual/plot), *Fordia unifoliata* (4.67 individual/plot) and *Vatica pauciflora*

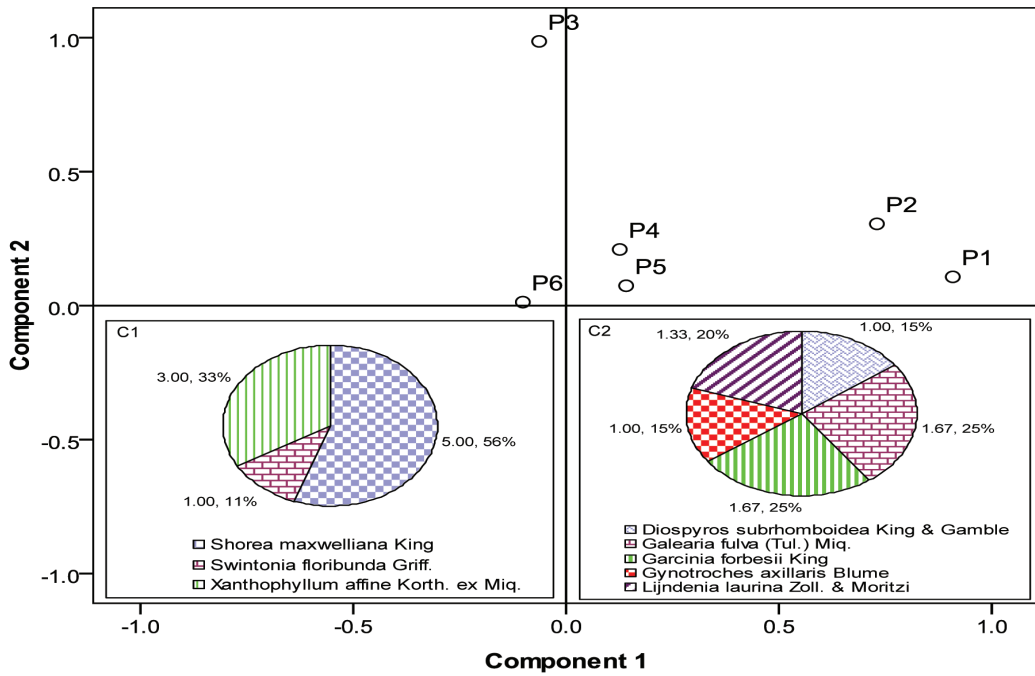


Fig.2. Species domination at the Herb (H)-layer in all plots

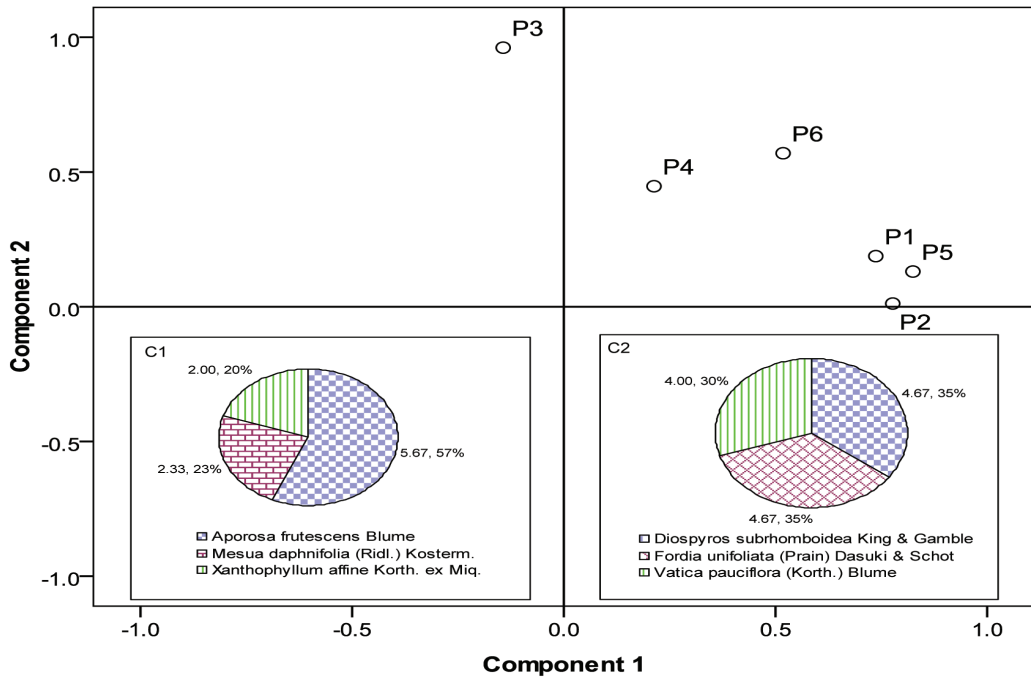


Fig.3: Species domination at the Shrub (S)-layer in all plots

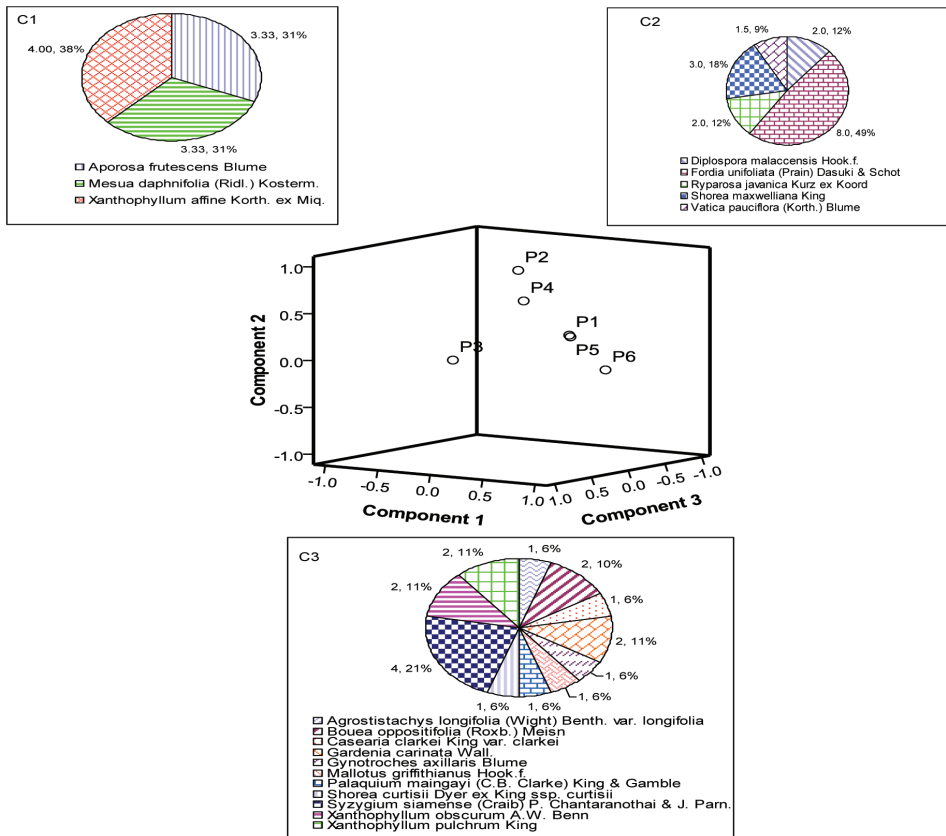


Fig.4: Species domination at the Co-dominant (T2)-layer in all plots

(4 individual/plot) are the main species of component 2.

There are three components at the T2-layer of component 1 (P1, P5 and P6), component 2 (P2 and P4) and component 3 (P3) (Fig.4). Component 1 consists of *Aporosa frutescens* (3.33 individual/plot), *Mesua daphnifolia* (3.33 individual/plot) and *Xanthophyllum affine* (4.00 individual/plot). *Diplospora malaccensis* (2 individual/plot), *Fordia unifoliata* (8.00 Individual/plot), *Ryparosa javanica* (2 individual/plot) and *Xanthophyllum pulchrum* (2 individual/plot), *Shorea maxwelliana* (3 individual/plot) and *Vatica pauciflora* (1.50 individual/plot) are the species at

component 2, whereas *Agrostistachys longifolia* (1 individual/Plot), *Bouea oppositifolia* (2 individual/plot), *Casearia clarkei* (1 individual/plot), *Gardenia carinata* (1 individual/plot), *Gynotroches axillaris* (1 individual/plot), *Mallotus griffithianus* (1 individual/plot), *Palaquium maingayi* (1 individual/plot), *Shorea curtisii* (1 individual/plot), *Syzygium siamense* and *Chantaranothai* (4 individual/plot), *Xanthophyllum obscurum* (2 individual/plot) and *Xanthophyllum pulchrum* (2 individual/plot) belong to component 3.

The T1-layer is divided into two components, namely, component 1 (P2,

P3 and P5) and component 2 (P1, P4 and P6) (see Fig.5). The species in component 1 are *Hopea latifolia* (4.67 individual/plot) and *Shorea maxwelliana* (6.33 individual/plot), whereas component 2 is made up of *Artocarpus lanceifolius* (1.33 individual/plot), *Diospyros rufa* (2.67 individual/plot), *Mesua daphnifolia* (2.33 individual/plot), *Swintonia spicifera* (3.33 individual/plot), *Vatica pauciflora* (3.67 individual/plot) and *Xanthophyllum affine* (2 individual/plot).

As it is in the T2-layer, the ST-layer consists of three components, of which component 1 comprises of P2, P3 and P5, while P1 and P4 are in component 2 and P6 belongs to component 3 (Fig.6). *Hopea latifolia* dominates P2, P3 and P5, with 2 individual/plot, while *Shorea maxwelliana* (1 individual/plot) and *Vatica pauciflora* (1.5 individual/plot) dominate in P1 and P4,

respectively. Component 3 is dominated by several species, namely, *Dipterocarpus grandiflorus* (1 individual/plot), *Hopea beccariana* (1 individual/plot), *Shorea curtisii* (3 individual/plot), *Shorea multiflora* (1 individual/plot) and *Swintonia spicifera* (1 individual/plot).

Generally, the correlation between DBH and height of every layer showed a positive relationship; high density followed by the increase in height ($r = 0.86$ p-value=0.00). The correlation at the S-layer is lower than the other layers; meanwhile, the r values increase (T1 and T2), and there is a decrease at the ST layer (Fig.7). The results contradict with the earlier statements which indicate that tree density is often negatively associated with mean or median tree size (Richards, 1952; Condit *et al.*, 1994). However, according to Denslow (1995), the

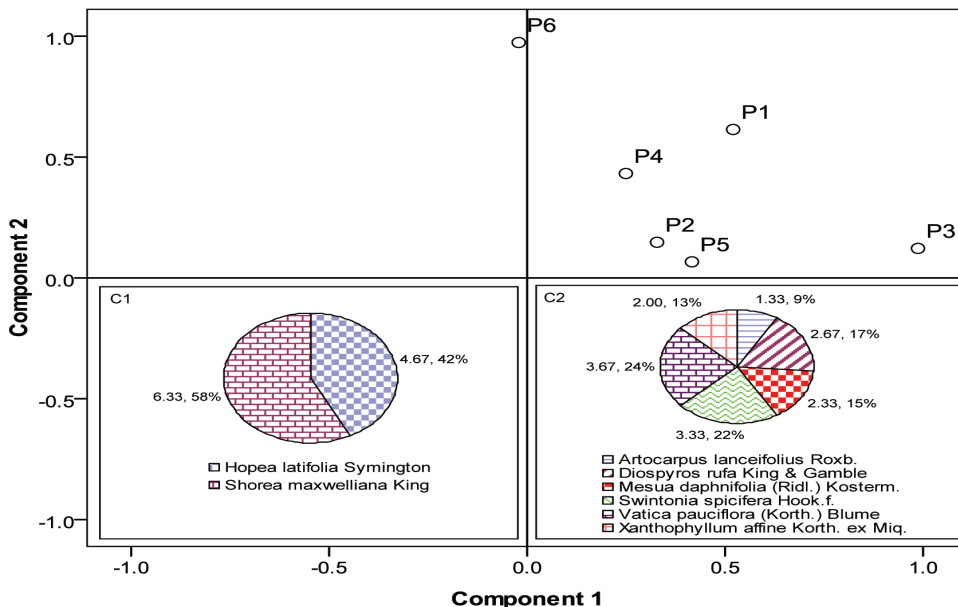


Fig.5: Species domination at the Dominant (T1)-layer in all plots

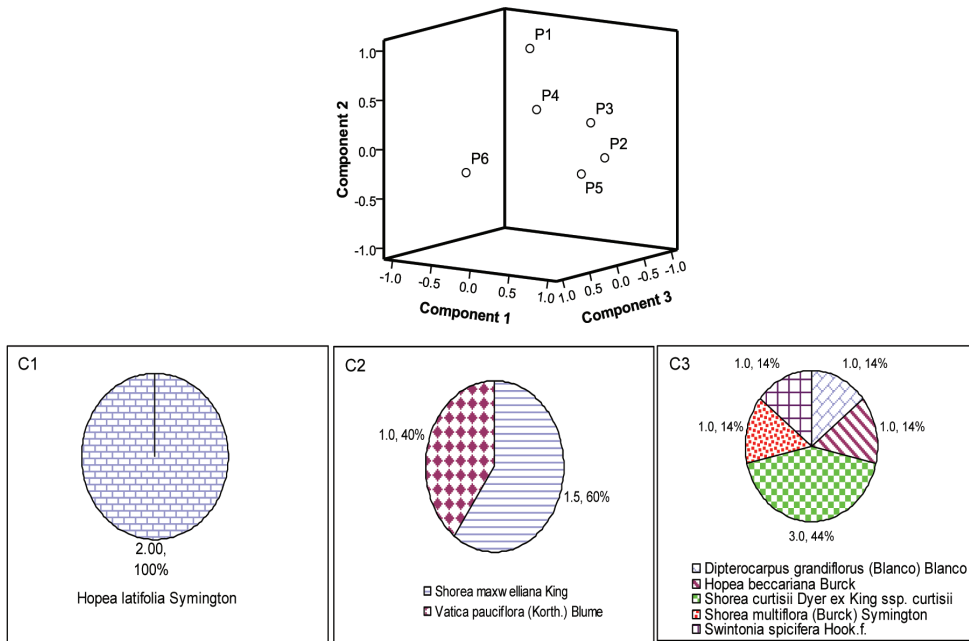


Fig.6: Species domination at the Emergent (ST)-layer in all plots

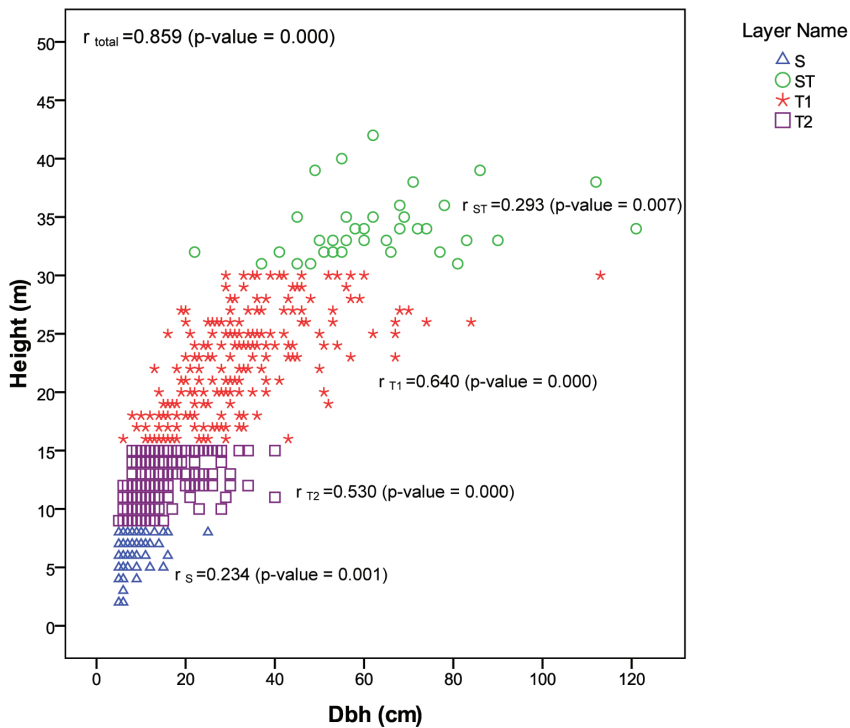


Fig.7: Relation between DBH and height at every layer level in all plots

process affecting tree size and density may also influence species diversity.

Only two (2) individuals of *S. lumutensis* are found in the T1 layer, while the presence of seedlings and saplings (in T2 and lower layers) is also small, reflecting a low regeneration or survival rate. Many rare plants are endangered in part because their populations are small. Small and isolated populations are inherently more vulnerable to natural catastrophes, demographic and environmental stochasticity (Holsinger, 2000; Lee *et al.*, 2004). In this study, the number of *S. lumutensis* is very alarming, with only 2 individuals in 1.5-ha plot, and this is apparently lower than the previously known population density of 4.4 trees ha⁻¹ (Boshier, 2011; Lee *et al.*, 2004). According to Boshier (2011), the rarity of *S. lumutensis* in Pangkor Island and its surrounding areas can be classified as locally common, but occurring in only a few places.

CONCLUSION

Conservation programmes on the Dipterocarps are on-going; for example, since 2001, the Forest Research Institute of Malaysia (FRIM) and International Plant Genetic Resources Institute (IPGRI) have been collaborating to explore the genetic diversity and to develop conservation strategies for *Shorea lumutensis*. The long-term goal of this project is to give scientific support to the design of new *in situ* conservation areas as well as to establish an *ex situ* conservation programme for the species.

Based on the species diversity characteristic at Pangkor HCVF, restoration and conservation efforts can be designed accordingly. In species restoration, recognizing straightforward performance from every species is an essential key. At the global scale, several schemes have been employed for identifying areas that may be particularly important for the long-term maintenance of biodiversity. As decision criteria, these schemes have variously used data on patterns of species richness, endemism, threat or taxonomic uniqueness of species, and habitat features. The specific community of the endemics must be redeveloped (i.e. through replanting of those species) in any *ex-situ* rehabilitation project. Development of HCVF covering all identified endemic species should be developed into a policy in the overall forest management plan in all states, which is in line with Strategy 11 of the National Policy on Biological Diversity launched in 1998. The area, which has been designated as HCVF must be big enough to provide buffer to protect the endemics, as in the case of *S. lumutensis* at Sungai Pinang Forest Reserve in this study.

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