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PHYTOSOCIOLOGY OF *AQUILARIA MALACCENSIS* LAMK. AND ITS COMMUNITIES FROM A TROPICAL FOREST RESERVE IN PENINSULAR MALAYSIA

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Abstract

A phytosociological study on the floristic and vegetation communities of *Aquilaria malaccensis* was carried out in Sungai Udang Forest Reserve, Malacca, Malaysia. The main objectives of this study were to identify, characterize and classify the *Aquilaria malaccensis* communities which were naturally distributed in the Sungai Udang Forest Reserve. A total of 25 plots (40 m x 20 m) in size were constructed according to the line transect method. The vegetation sampling and data analysis were done. A total of 80 species belonging to 79 genera and 40 families were found from all the 25 plots in Sungai Udang Forest Reserve. The most abundant family was the Euphorbiaceae with 220 individual trees, followed by Myrtaceae and Anacardiaceae representing 212 and 197 individual trees, respectively. A community which was *Aquilaria malaccensis – Artocarpus rigidus* community with two new sub-community known as *Palaquium gutta* sub-community and *Barringtonia racemosa* sub-community were identified on the basis of statistical and phytosociological analyses. These community and sub-community also showed preference on different geographical and environmental factors such as soils and local relief. This study is useful in providing more information on the growth response of the mixed dipterocarp forest in the development of proper forest management.

Key words: *Aquilaria malaccensis,* Braun-Blanquet, Peninsular Malaysia, Phytosociology, Vegetation community.

Introduction

Phytosociology provides useful basic data for ecology, geography, landscape science, conservation and environmental science because the data represent integrated units in vegetation systems (Fujiwara, 1987). A phytosociological study gives information on the distribution of species as well as affinities between species or group of species, resulting in a valuable evaluation of the vegetation (Frenedozo-Soave, 2003).

Phytosociology involves plant communities within the same environment, their floristic composition and development, and the social relationships between them (Sarah *et al.,* 2015). A favourable growing conditions means the existence of a rich floristic diversity and any ecological and plant resource management requires the involvement of a list of species (Hussain *et al.*, 2015). The planning, management and exploitation of natural resources are assisted by phytosociological surveys (Haq *et al.*, 2015). Classification of natural ecosystems into potential plant communities and habitat types is important for the long term management of natural resources (Khan *et al.*, 2011).

Enright & Nuñez (2013) stated that Braun-Blanquet pioneered the classification of vegetation into units (associations) based on floristic composition and the identification of characteristics species. The advantages, and problems, associated with the phytosociological approach to vegetation analysis pioneered by Braun-Blanquet have been reviewed many times, and inevitably will continue to do so as the vegetation science community increasingly becomes a globalized one.

The principal plant used in this study is *Aquilaria malaccensis* Lamk. (or known locally as 'Karas'). *Aquilaria malaccensis* ranks among the most highly valuable non-timber products harvested from tropical forests and used in the manufacture of perfume, incense, traditional medicine, and other commercial products by Muslims and Asian Buddhists (Turjaman *et al.,* 2006). The aromatic resin known locally as 'gaharu' yield an essential oil that is a key perfume ingredient through distillation, meanwhile, incense are commonly processed from distillation residues and lesser quality material.

Aquilaria malaccensis is a major producer of agarwood in Malaysia for international trade (Wong *et al.,* 2013). Some of the well-known natural populations of *Aquilaria malaccensis* in Malaysia are Sungai Udang in Melaka, Bukit Bauk in Terengganu, Gua Musang in Kelantan, Jelebu in Negeri Sembilan, and Jeli in Kelantan (Lee *et al.,* 2011).

Aquilaria malaccensis is absent from Sarawak while other species of this genus are reported rare (Tawan, 2004). Logging activities and ongoing forest conversion in Sumatra and Kalimantan might account for low densities of *Aquilaria* spp. in these two regions, although anecdotal evidence suggests that concessionaires do not fell *Aquilaria* species as the wood is not valuable for plywood (Soehartono & Newton, 2000).

Many studies have reported a reduction in the natural populations of *Aquilaria malaccensis* due to the high demand of agarwood. As a result, this species is classified as 'vulnerable' by the International Union for the Conservation of Nature (Anon., 2002). To make matter worse, *Aquilaria malaccensis* have been listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Anon., 2011).

This endemic genus with restricted distributions has received concerns from foresters, biologists and naturalists who aim at conserving these species in the wild (Lee *et al.,* 2011). Overexploitation of the species in their natural environments is expected to be reduced by the development of massive *ex-situ* plantations combined with techniques able to induce agarwood production on young plants (Faridah-Hanum *et al.,* 2009).

The tropical rain forest plants contain diverse resources of biologically and chemically important components as they synthesize various chemicals as defense agents against pests, diseases and predators (Danial *et al.,* 2013). One way to conserve this valuable tropical tree would be to produce agarwood in a sustainable manner by mass planting the trees and collecting agarwood in non-destructive manner (Mohamed *et al.,* 2010). Thus, the knowledge gained from phytosociology study will contribute to the mass planting of *Aquilaria malaccensis* and indirectly could contribute to the conservation efforts.

Currently, research on the phytosociology of *Aquilaria malaccensis* such as detailed studies on its floristic aspects and its plant community level is literally unknown. In view of these, the main objectives of this study were to identify, characterize and classify the *Aquilaria malaccensis* and its communities which were naturally distributed in Sungai Udang Forest Reserve.

Materials and Methods

Study area: Phytosociological data of *Aquilaria malaccensis* trees were obtained from a forest reserve at Sungai Udang, Malacca, Malaysia (2°19′N, 102°8′E) (Fig. 1). The Sungai Udang Forest Reserve is a lowland Dipterocarp forest and is home to various flora and fauna. The trees were all within walking distance within a 100 m in radius. The data were collected within the boundary of 20 hectares of forest reserve known as Compartment 4 which were considered representative of *Aquilaria malaccensis* communities. The study areas in Compartment 4 are protected from any logging activities. Sungai Udang Forest Reserve was announced in 1987 as Permanent Forest Reserve area of the remaining approximately 335 acre of land area. The area has a rough topography and ranges in altitude from 10 to 90 m. The area has a tropical rainforest climate which is punctuated by much rainfall. The rainy seasons or heavy monsoon season occurs on October through March every year. The dry season occurs from May through July every year. The weather is warm and humid all year round with temperatures ranging from 21°C to 32°C. Mean annual rainfall of the study area was recorded as 2000 mm and it is considered as one of the driest area in Malaysia. Mean annual maximum and minimum precipitation was recorded as 74% and 35%, respectively. The relative humidity typically ranged from 54% to 96% throughout the year.

Vegetation sampling: Field surveys and data collection were done based on the techniques described by Braun-Blanquet (1964) and Fujiwara (1987). Fieldwork was carried out from September 2012 to November 2012 and from January 2013 until April 2013. A total of 25 plots (20 x 40 m) in size were constructed according to the line transect method. The size of the plot was estimated by means of a "minimal area" which was 800 m^2 in each plot. Plots were 20m separated from each other. The plots were located at various altitudes, expositions, inclinations, and relief. An effort was made to achieve high ecological and physiognomic homogeneity within each plot. Every plot was georeferenced with a Garmin GPS. Scientific names of each vascular species in each plot were determined. Cover or abundance data of all vascular plant species for each plot were verified using the Braun-Blanquet (1964) method. All vascular plant species in each plot with a trunk diameter at breast height (DBH) ≥5 cm were marked and numbered, and their diameters and heights were recorded. Trunk perimeter measurements were taken using a metric tape and tree height was estimated with the aid of a clinometer. These samples were classified in a phytosociological table according to their floristic composition. The vegetation layers in the forest were divided into five layers as shown in Table 1.

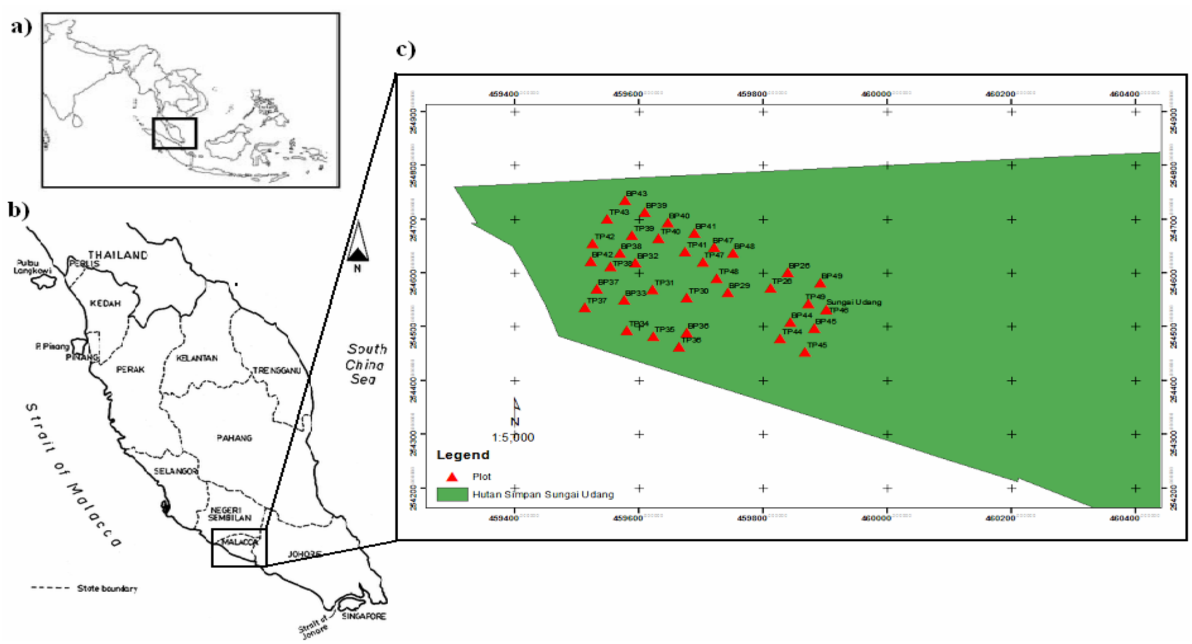

Fig. 1. (a) Map of Southeast Asia outlining the Peninsular Malaysia, (b) map of Peninsular Malaysia showing the location of the study site, and (c) map of the study site within the Sungai Udang Forest Reserve (Malacca, Malaysia). Triangles indicate the locations of sampling plots in the study site.

Table 1. Types of vegetation layers.

Vegetation layers	Height
Super tree (ST)	≥30m
Canopy tree layer (T1)	10-25m
Understory tree layer (T2)	6-9m
Shrub layer (S)	2-5m
Herb layer (H)	0.1-2m

Data analysis: As for the numerical analysis, the cover or abundance values on the scale of Braun-Blanquet were transformed into the 1–9 ordinal scale of van der Maarel (1979). With the goal of identifying the floristic composition of these groups, this synthetic phytosociological table was elaborated by scoring species in percentage or constancy classes, according to Braun-Blanquet's scale. Lastly, the communities of the species were described based on all the 25 plots that were surveyed (Fig. 2).

Results and Discussion

Community structure and floristic composition: A total of 80 species belonging to 79 genera and 40 families were found in all the 25 plots. The most abundant family was Euphorbiaceae with 220 individuals trees, followed by Myrtaceae and Anacardiaceae representing 212 and 197 individual trees, respectively. The most dominant species was *Syzygium* sp. (Myrtaceae) followed by *Elateriospermum tapos* (Euphorbiaceae) and *Spondias cytherea* (Anacardiaceae), respectively. A community known as *Aquilaria malaccensis – Artocarpus rigidus* community and two sub-communities were determined in this study as shown in the community table (Table 2).

***Aquilaria malaccensis – Artocarpus rigidus* community:** A total of 10 species belonging to 10 genera and 10 families were found in the *Aquilaria malaccensis – Artocarpus rigidus* community. The forest vegetation of this community was commonly distributed at altitudes of 30 m to 87 m. The pH of the soil of this community ranged from 4.11 to 4.95 for all the 25 plots clearly indicated that the soil had an acidic character. The soil of the community had high organic matter, rich in available macro elements such as Ca, K and P and is sandy-loamy, loamy in texture. This community exhibited 3 vegetation layers which were tree, shrub and herb layers. The tree layer was 15 m – 40 m high, with a 65%-55% general cover. The shrub layer was 2 m - 10 m high, with a 20%-35% general cover. Total coverage of the herb layer was between 15% and 25%, and reaches below 2m in height. The characteristic and differential species of the community were *Aquilaria malaccensis, Knema* sp.*, Swintonia schwenkii, Ochanostachys amentaceae, Ixonanthes icosandra, Adina* sp.*, Gironniera nervosa, Artocarpus rigidus, Garcinia* sp. and *Baccaurea parviflora*.

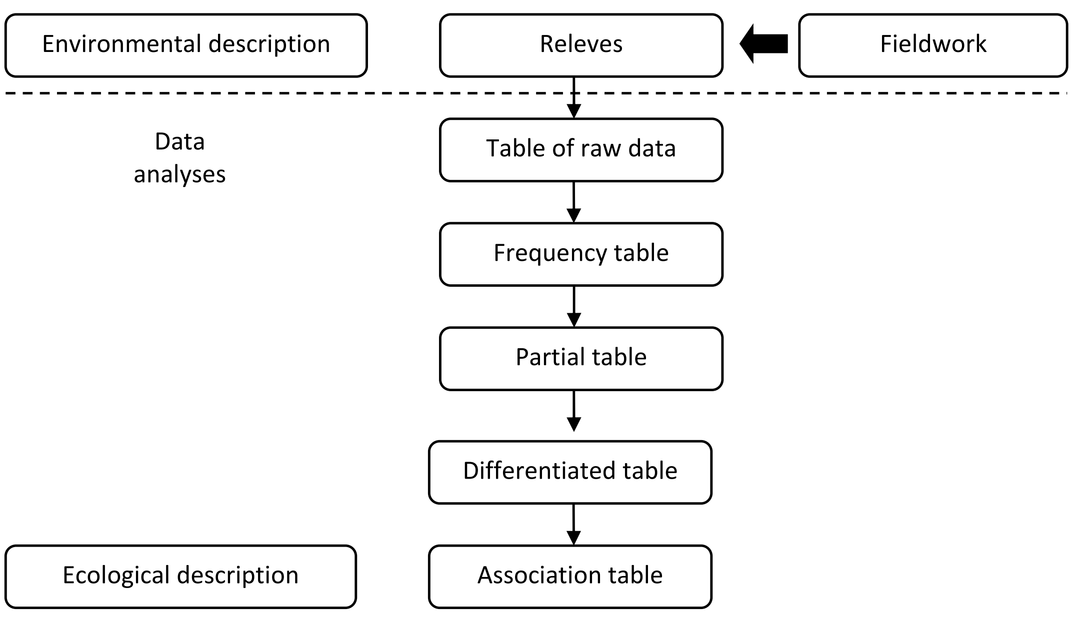

Fig. 2. Flowchart of data analyses according to the classical method of Braun-Blanquet (1964) and van der Maarel (1979).

Table 2. The *Aquilaria malaccensis – Artocarpus rigidus* community and its sub-communities of the study area.

Releve number	3	4	6	24	23	17	7	14	15	18	19	9	13	16	8	10	11	12	5	1	2	20	21	22	25
Area (m2) x 10	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Altitude (m)	57	54	60	87	75	80	61	67	73	77	70	59	56	64	60	55	59	60	56	50	53	55	62	64	58
Inclination (°)	10	10	20	20	20	20	15	15	15	20	20	10	10	15	15	15	15	15	15	15	15	15	15	15	15
Average height of tree layer (m)	27	26	33	31	29	32	30	28	30	31	30	29	28	32	29	27	30	31	29	29	24	28	30	31	26
Average height of shrub layer (m)	11	11	13	12	12	11	12	12	13	13	13	12	12	10	13	13	13	13	12	10	10	12	13	13	12
Average height of herb layer (m)	4	2	4	4	-	-	4	4	-	-	-	4	4	-	-	4	4	4	4	-	2	-	4	-	4
Differential species of the community																									
Aquilaria malaccensis	3	2	2	2	2	.	4	3	.	3	3	,	3	.	2	.	3	2	1	2	.	3	+		+
Swintonia schwenkii	.	.	.	+	1	3	1	+	1	+	+	1	+	2	1	1	.	+	2	.	.	+	.	2	+
Knema sp.	1	1	1	+	+	+	+	.	+	.	+	+	+	+	2	+	.	1	+	.	.	.	+		
Ixonanthes icosandra	1	1	.	2	+	2	2	+	+	.	.	+	.	.	2	+	+	.	1	1	.	+	.	.	+
Ochanostachys amentaceae	+	.	1	+	+		1	+	+	.	+	.	1	+	+	.	+	.	2	1	.		.	+	+
Artocarpus rigidus	.	.	2	2	2	3	1	2	2	2	3	2	.	.	2	+	.	1	+	.	.	+	2	.	.
Garcinia sp.	+	+	.	+	.	+	+	.	+	1	+	.	1	.	2	.	2	1	.	.	.	2	.	2	+
Gironniera nervosa	2	+	.	.	.	+	.	+		+	+	1	1	.	.	+	+	+	.	+	.	2	+	2	.
Adina rubescens	2	.	.	+	.	.	.	+	+	2	+	1	.	.	1	1	+	+	+	.	.	+	+	+	.
Baccaurea parviflora	1	1	+	+	+	+	+	.	.	.	.	+	.	+	1	+	+	.	1	.	.	+	.	.	.
Differential species of *Palaquium gutta* sub-community																									
Palaquium gutta.	2	.	.	.	.	.	1	4	.	2	2	+	4	.	.	.	.	.	.	.	.	.	.	.	.
Gordonia concentricicatrix	.	.	2	.	2	.	.	.	2	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Lithocarpus sp.	.	+	.	2	.	.	2	2	2	.	.	4	+	.	.	.	.	.	.	.	.	.	.	.	.
Sarcotheca monophylla	+	+	+	.	2	3	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Endospermum diadenum	2	1	+	.	.	.	3	.	+	.	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Pternandra echinata	+	+	.	.	.	.	.	+	+	2	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Diospyros rigida	.	.	2	+	.	.	3	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Dialium kingii	.	.	3	2	.	+	1	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sandoricum koetjape	.	.	1	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pithecellobium splendens	.	.	1	.	.	+	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Memecylon sp.	.	.	.	.	.	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Durio sp.	1	+	+	.	.	.	+	2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Pellacalyx sp.	.	.	.	.	.	2	.	+	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Xanthophyllum sp.	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 2. (Cont'd.).

Releve number	3	4	6	24	23	17	7	14	15	18	19	9	13	16	8	10	11	12	5	1	2	20	21	22	25
Differential species of *Barringtonia racemosa* sub-community																									
Barringtonia racemosa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	.	.	.	.	.	.
Calophyllum marcocarpum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	2	1	+	.	+	.	.
Streblus elongates	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	+	+	.	.	.	.	2	+
Elaeocarpus nitidus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	2	1	.	.	2	.	.
Polyalthia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.	.	.	2	2	2	+	.	+	.
Artocarpus elasticus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	.	1	2	.	.	.	.
Diospyros argentea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	+	+	+	.	.	.	.	+
Adenanthera pavonina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	+	2	+
Shorea leprosula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	2	+	.	.	.	2	2	.	.
Azadirachta excelsa	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	3	.	.	2	.	.	.
Cratoxylum arborescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	+	.	.	.	.	+	2	.	.
Ixonanthes reticulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	3	.	+	2	.	+	2	.	.
Characteristics species of higher units																									
Eurycoma longifolia	.	.	+	.	+	+	+	+	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.
Macaranga gigantia	.	.	.	.	+	+	.	+	.	.	.	2	.	.	+	.	+	.	.	.	.	2	.	.	.
Ixora sp.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Mesua ferrea	.	+	1	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Rhodamnia cinerea	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	+	.
Koompassia malaccensis	.	2	.	2	.	.	3	.	.	.	.	.	.	.	.	.	.	.	2	.	.	+	.	.	.
Cyathocalyx sp.	.	.	.	.	.	.	1	.	.	.	+	+	.	.	.	1	+	.	.	.	.	.	.	.	.
Gynotroches axillaris	.	.	.	.	.	.	.	.	+	+	.	1	.	.	1	.	3	.	.	.	.	.	.	.	.
Callerya atropurpurea	.	.	.	+	.	.	.	+	.	.	2	.	.	.	.	2	.	.	.	.	.	.	2	.	.
Oncosperma tigillarium	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	2	+	.	+
Baccaurea macrocarpa	.	.	.	.	.	.	.	+	.	+	.	.	.	2	.	.	.	.	.	+	.	.	.	.	.
Ardisia sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	+	.
Swintonia penangiana	.	+	2	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.
Artocarpus scortechinii	.	1	.	.	.	2	.	.	.	.	.	2	.	+	.	.	.	.	.	.	.	.	.	.	.
Xerospermum noronhianum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	1	.	.	.	.	2	.
Hopea sp.	.	.	.	.	.	.	.	+	4	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.

Table 2. (Cont'd.).

Releve number	3	4	6	24	23	17	7	14	15	18	19	9	13	16	8	10	11	12	5	1	2	20	21	22	25
Companion species																									
Blumeodendron subcaudatum	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ficus sp.	2	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Sapium baccatum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2
Dillenia sp.	.	.	.	.	+	+	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sindora sp.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Pandanus sp.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Aglaia sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bouea macrophylla	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paratocarpus bracteatus	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	3	.
Dacryodes rugosa	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hydnocarpus elmeri	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lansium sp.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Buchanania subobovata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.
Drypetes sp.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.
Scaphium macropodum	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Heritiera sp.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	.	.	.	.	.	.	.	.	.
Saraca sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Terminalia sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adinandra sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Antidesma sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Urophyllum glabrum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bouea oppositifolia	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dysoxylum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Pertusadina eurhyncha	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parkia javanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.
Xylopia fusca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Neesia altissima	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Flacourtia rukam	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Aquilaria malaccensis trees in Sungai Udang Forest Reserve had been wounded or injured by the native people using traditional means in their attempt to gather agarwood (Mohamed *et al.,* 2010). Nevertheless, despite being wounded or the existences of a few clear areas and canopy openness due to tree felling, the *Aquilaria malaccensis* – *Artocarpus rigidus* community was protected against unconscious cutting and over-grazing due to its status as a natural park. This study shows that *Palaquium gutta, Endospermum diadenum, Agrostistachys longifolia* and several other species can be found in all the four vegetation layers and in several plots. Most of these species showed that they grow in colonies or in certain population. The trees of some species could grow as a group and spread across several plots (Kwan & Whitmore, 1970). Despite the existence of some species that were commonly distributed, this community also showed several species that have occurred only once or twice in all plots. This factor suggested that the tropical forest consisted of many aggregated species and small numbers of randomly distributed species (Hubbell 1979; Masaki *et al.,* 1992; Tanouchi & Yamamoto 1995; Yamamoto *et al*., 1995).

***Palaquium gutta* sub-community:** A total of 14 species belonging to 14 genera and 13 families were found in the *Palaquium gutta* sub-community. This sub-community occurred at altitudes of 30 m to 82 m. This sub-community was found on flat areas or slightly undulating terrain which occured on ridge area (0-10 degree). The soil of this sub-community had an acidic character, high organic matter and was loamy in texture. The coverage rates of tree, shrub, and herb layers were 70%-80%, 10%-20%, and 10%-25%; and the average heights were 30 m, 10 m, and 2 m, respectively. The characteristic and differential species of this subassociation were *Palaquium* sp., *Gordonia concentricicatrix*, *Lithocarpus* sp., *Sarcotheca monophylla, Endospermum diadenum, Pternandra echinata, Diospyros rigida, Dialium kingii, Sandoricum koetjape, Pithecellobium splendens, Memecylon* sp., *Durio* sp., *Pellacalyx* sp., and *Xanthophyllum* sp.

Some of the plots in *Palaquium gutta* sub-community were situated at the forest area with canopy gaps due to disturbance caused by branch and tree fall. These small and large gaps by all sizes of trees from small branches to large trees were created by strong windstorms. Large trees might be important for the formation of frequent and huge canopy gaps in primary forest (Numata *et al.,* 2006). Natural disturbances in tropical forest can be of different scale such as from the impact of a single fallen tree to the extent of the destruction of several hundred km^2 (Ting and Poulsen, 2009). Some invasive plant species penetrated into the floristic structure of this sub-community due to the effect of canopy openness. The removal of canopy trees inevitably increases light availability in the understory, thus facilitating invasion by light-demanding species (Padmanaba & Corlett, 2014).

***Barringtonia racemosa* sub-community:** A total of 12 species belonging to 12 genera and 11 families were found in the *Barringtonia racemosa* sub-community. This sub-community occurred at altitudes of 34 m to 61 m on slope areas (11-20 degree). The soil of this sub-community consisted of the limeless brown soil and this soil was acidic and loamy in texture. This sub-community was composed of tree, shrub and herb vegetation layers. The general coverage of the tree layer ranged from 75% to 90%, and heights ranged from 20 m to 35 m. Total coverage of the shrub layer was from 10% to 30%, and ranged from 10 m to 15 m in height. Coverage of the herb layer ranged from 10% to 20%, and heights ranged from 2 m and below. The characteristic and differential species of this subassociation were *Barringtonia racemosa, Calophyllum marcocarpum, Streblus elongatus, Elaeocarpus nitidus, Polyalthia* sp., *Artocarpus elasticus, Diospyros argentea, Adenanthera pavonina, Shorea leprosula, Azadirachta excelsa, Cratoxylum arborescens,* and *Ixonanthes reticulata*.

The soil of *Barringtonia racemosa* sub-community had a slightly basic character and low electrical conductivity, calcium carbonate, and K. Due to unfavourable environmental conditions such as high inclination and erosion, available macroelements (Ca, K, Mg, and Na), organic matter and salt were low. Steep slope also promoted and triggered the formation of a few landslip or landslide in the sub-community area. As a result, the floristic composition of this sub-community was poor. Phytosociological characters differ among aspects and position, even in the same vegetation type (Khan *et al.,* 2010). Species richness was lower in the communities nearby water sources suggesting intensive grazing and tramping than in the typical community of the drier zone. The distribution and abundance of plant species are influenced significantly by human and animal impacts (Ghazal, 2015). This factor suggested that grazing had changed the floristic composition and decreased the species richness in the area (Cheng *et al.*, 2013). Disturbance would reduce the potential height of trees from 25% to 50% (Ng, 1983). Floodplains, formed mainly of river sediments and subject to flooding, occurred during the rainy season at certain areas of low lying ground adjacent to the small stream of the *Barringtonia racemosa* sub-community, had contributed to the decrease of species richness in the area. Floods might contribute to the lower density of tree species in riverine and seasonal flood forests which would affect the growth of seedlings or saplings or even can lead to the destroy of the small trees (Khairil *et al.,* 2014). As a result of long flooding periods, floristic composition of a particular association may be changed (Yalcin *et al.,* 2014). Species composition and their population level fluctuate from year to year depending on the rains (Perveen *et al.,* 2008).

Conclusions

From the results of the present study it can be concluded that an excellent way to conserve this valuable tropical tree and its communities would be to know its composition and the ecological relationship between the species within its communities, and this could be achieved with a phytosociological studies.

The vegetation communities in Sungai Udang Forest Reserve needs prior conservation to sustain its diverse flora, and the restoration of *Aquilaria malaccensis* and its communities will become more feasible with all the basic information of the vegetation communities obtained from this phytosociological study.

High soil fertility promotes high species diversity and richness of an area. Therefore, soil characteristics of an environment should be the important criteria for its species distribution. The composition and distribution of species in this study could also be influenced by other environmental factors such as natural forest gap, altitude and the topography. This study is only a preliminary research, thus, further research should be made on those mentioned factors especially regarding the soil characteristics.

The lack of scientific information on the phytosociology study of vegetation in Malaysia made it very difficult to compare the floristic similarity of the association described in this study with other possible similar studies.

Thus, this study is useful as a main stimulus for further botanical documentation and to provide more information on the growth response of the mixed dipterocarp forest for the development of proper forest management. Besides that, this study also provides a better insight into the composition, distribution of the plant communities and of the main threats to their conservation.

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