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Community Structure and Biomass of Tree Species at Chini Watershed Forest, Pekan, Pahang

(Struktur Komuniti dan Biojisim Spesies Pokok di Hutan Lembangan Chini, Pekan, Pahang)

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ABSTRACT

A study was conducted to determine the tree species composition, diversity and estimate of above ground biomass at Chini watershed forest. Three types of forest were identified. Thirty plots of 0.1 ha were established in the inland, seasonal flood and riverine forests. A total of 3974 trees with diameter at breast height (dbh) at 5.0 cm and above were recorded. The inland forest recorded 2061 individuals representing 393 species from 164 genera and 57 families; the seasonal flood forest, 1019 individuals representing 268 species from 137 genera and 57 families; and the riverine forest, 894 individuals representing 260 species from 133 genera and 53 families. Endospermum diadenum *(Euphorbiaceae),* Streblus elongatus *(Moraceae) and* Aporusa arborea *(Euphorbiaceae) was the most important species in the inland forest, seasonal flood forest and the riverine forest, with Importance Value Index (SIV_i) of 3.36%, 4.43% and 2.96%, respectively. Euphorbiaceae was the most important family in the inland and riverine forest with FIV_i of 14.25% and 12.91% and Myrtaceae in the seasonal flood forest at 12.36%. The Shannon-Weiner diversity index (H') were considered high in all three forest types at 5.40 (H'_{max} = 5.97) in the inland forest, 5.10 (H'_{max} = 5.54) at the seasonal flood forest and 5.08 (H'_{max} = 5.56) for the riverine forest. Shannon evenness index (J') in the three types of forest was 0.9. The Sorenson's community similarity coefficient (CCs) showed that tree species communities between the three forest types had low similarities with CCs= 0.4. The total above ground biomass estimated in the inland forest was 366.2 tan/ha, in the seasonal flood forest was 379.8 tan/ha and in the riverine forest was 401.1 tan/ha. A total of 44 endemic species in Peninsular Malaysia were found and 104 species were listed in the checklist of Conservation Status of Malaysian Trees that utilized the 2009 IUCN Red List Categories by World Conservation Monitoring Centre (WCMC).*

Keywords: Chini watershed; community similarity; species diversity; tree species biomass; tree species composition

ABSTRAK

Satu kajian telah dijalankan untuk menentukan komposisi, kepelbagaian dan anggaran biojisim atas tanah spesies pokok di hutan lembangan Chini, Pekan, Pahang. Terdapat tiga jenis hutan telah dikenal pasti di lembangan Chini iaitu hutan pedalaman, banjir bermusim dan riparia. Sebanyak 30 plot yang bersaiz 0.1 ha telah dibina dengan jumlah luas kawasan pensampelan di hutan pedalaman adalah 1.4 ha, hutan banjir bermusim 0.9 ha dan hutan riparian 0.7 ha. Sejumlah 3974 pokok bersaiz 5 cm dbh dan ke atas telah dicatatkan. Hutan pedalaman merekodkan 2061 individu, 393 spesies daripada 164 genus dan 57 famili; hutan banjir bermusim, 1019 individu, 268 spesies daripada 137 genus dan 57 famili; dan hutan riparia, 894 individu, 260 spesies daripada 137 genus dan 53 famili. Endospermum diadenum *(Euphorbiaceae),* Streblus elongatus *(Moraceae) and* Aporusa arborea *(Euphorbiaceae) merupakan spesies yang mempunyai Nilai Kepentingan (SIV_i) spesies tertinggi di hutan pedalaman, hutan banjir bermusim dan hutan riparia dengan masing-masing 3.36%, 4.43% dan 2.96%. Euphorbiaceae merupakan famili terpenting di hutan pedalaman dan hutan riparia dengan Nilai Kepentingan (FIV_i) famili masing-masing 14.25% dan 12.91% dan Myrtaceae di hutan banjir bermusim dengan 12.36%. Nilai indeks kepelbagaian Shannon-Weiner (H') yang dicatatkan didapati tinggi di ketiga-tiga jenis hutan dengan hutan pedalaman 5.40 (H'_{max}= 5.97), hutan banjir bermusim 5.10 (H'_{max}= 5.54) dan hutan riparia 5.07 (H'_{max}= 5.56). Nilai keseragaman Shannon (J') ketiga-tiga jenis hutan ialah 0.9. Koefisien kesamaan komuniti Sorenson (CCs) menunjukkan komuniti di ketiga-tiga jenis hutan mempunyai nilai kesamaan yang rendah iaitu CCs= 0.4. Jumlah biojisim atas tanah di hutan pedalaman ialah 366.2 tan/ha, di hutan banjir bermusim 379.8 tan/ha dan di hutan riparia 401.1 tan/ha. Sejumlah 44 spesies endemik di Semenanjung Malaysia telah dikenalpasti hadir dalam kajian ini dan sebanyak 104 spesies pokok telah disenaraikan dalam senarai pemuliharaan IUCN Red list Categories 2009 oleh World Conservation Monitoring Centre (WCMC).*

Kata kunci: Kepelbagaian spesies; kesamaan komuniti; komposisi spesies pokok; lembangan Chini

Introduction

Wetlands include both land ecosystem whose ecological function is strongly influenced by water, and aquatic ecosystem with special characteristics due to its shallowness and the proximity to land (Lugo et al. 1990; Roggeri 1995). Their often rich variety of resources makes them highly valuable to the peoples who live or regularly stay in them. During the last few decades tropical wetlands have been destroyed or considerably altered. Dams and embankments now prevent water from spreading into the floodplains of several rivers, like the Senegal, Volta and Nile. In Southeast Asia, the wetland areas in many countries have been destroyed by activities such as agriculture, logging and development (Roggeri 1995; Williams 1990).

Malaysia is one of the countries that have wetland areas and it was estimated about 3.3 million ha that is equal to only 10% of the total area of the country (Wetlands International 2009). The important freshwater habitats in the country are the highland forests and wetlands (both forested wetlands and water bodies such as rivers, lakes and lagoon). Forests in the highlands, often referred to as natural 'water towers' because of their water catchment function help provide us with continuous clean supply of water. They are the source for most of the country's water resources (Wetlands International 2009). Wetlands provide a range of natural ecological and hydrological functions therefore they have important roles in water supply, water purification and flood control (Roggeri 1995; Walter 2002).

Both the highland forests and wetlands also contribute many socio-economic benefits in terms of the goods and services (such as forestry and fisheries resources). They also serves as critical biodiversity conservation needs such as by providing refuge for many species of plants and animals (Lugo et al.1990; Roggeri 1995; Williams 1990). One of the efforts by the Malaysian government and international societies in order to conserve the wetland areas was by the declaration of Tasik Bera in Pahang, Sungai Pulai, Tanjung Piai and Pulau Kukup in Johor and Kuching Wetland National Park as Ramsar Sites (Wetlands International 2009).

Pahang is the largest state in Peninsular Malaysia and the forest covered 3,596,585 ha that is equal to 42.7% of the total area of Pahang (Jabatan Perhutanan Semenanjung Malaysia 2008). There were two natural lakes in Pahang namely, Tasik Bera and Tasik Chini. Tasik Chini is the second largest natural freshwater lake in Peninsular Malaysia after Tasik Bera. The Chini watershed includes several small rivers and stream, a lake, swamps and lowland forests. For over 30 years, people have visited the Tasik Chini for fishing, kayaking, camping, jungle tracking and visited the Orang Asli settlements (Mohd Ekhwan et al. 2009). Tasik Chini is inhabited by Orang Asli from Jakun tribe for a long time.

Chini watershed forests harbour both aquatic and terrestrial species biodiversity (Mushrifah et al. 2005; 2009). Hence, Tasik Chini has been declared as one of the eco-tourism sites in Pahang (Rancangan Tempatan Daerah Pekan 2002-2015). However, activities such as timber harvesting, oil palm plantation, infrastructure development and mining in Chini watershed forests had disturbed the ecosystem balance (Mushrifah et al. 2005). These activities also cause habitat loss of flora and fauna and gave negative impacts on the indigenous people, who tend to hunt wildlife, find rattans and other plants as daily livelihood and also as traditional medicine (Mustaffa 2005).

The degradation of both aquatic and terrestrial components of the Chini ecosystem has led to many studies. Most studies at Chini concentrated on the aquatic component (e.g. Khatijah 2005; Mushrifah et al. 2005, 2009; Suhaimi et al. 2009). There are very few studies on the terrestrial component especially on the forest structure of the watershed forests that surround the lake. There are several studies on tree species composition and diversity at Chini Forest Reserve. Siti Najmi (2005) conducted a study at an inland forest of Sg. Jemberau, Norwahidah (2005) conducted a comparative study between riparian and inland forest of Sg. Chini, Fajariah (2004) at inland forests of Bukit Tebakang and Norsiah (2005) at riparian forests of Sg. Chini. All those studies covered a small local scale and limited area only. Thus, this study was conducted to cover a larger landscape scale of vegetation characterization at the Chini watershed forests, Pekan, Pahang.

The objectives of this study were to determine the trees species composition, diversity and above ground biomass in Chini watershed forest. As an area that has been declared as a Man and Biosphere Reserve site by UNESCO, Tasik Chini needs a lot of baseline data that can be used to conserve this area. Therefore, the endemism and conservation status of tree species were also included in the study. Besides that, Tasik Chini is one of the areas that will be developed under the East Corridor Economic Region (ECER) project as Chini State Park. Thus, the data and information on tree species community structure and diversity from this study is very important and will be used as a guideline for a sound management plan and conservation activities at Chini.

Methodology

The Tasik Chini basin includes a lush tropical regenerating logged-over forest covering an area of 4975 ha from which, many rivers and streams feed the lake (Figure 1.). The area of the lake is not constant and the area can be between 150 and 350 ha due to flooding especially during the raining season between October to November (Chong 2001). Based on the information given by the villagers, during the flooding season, the water level of the lake can increase up to 1-2 meter in height than the norms. The lake system comprises of 12 open water bodies. Generally, most of the area is at low altitude whereby almost 80% of the area is below 250 m except for areas at Bukit Chini that has the highest peak of 641m (Wetlands International Asia Pacific 1998).

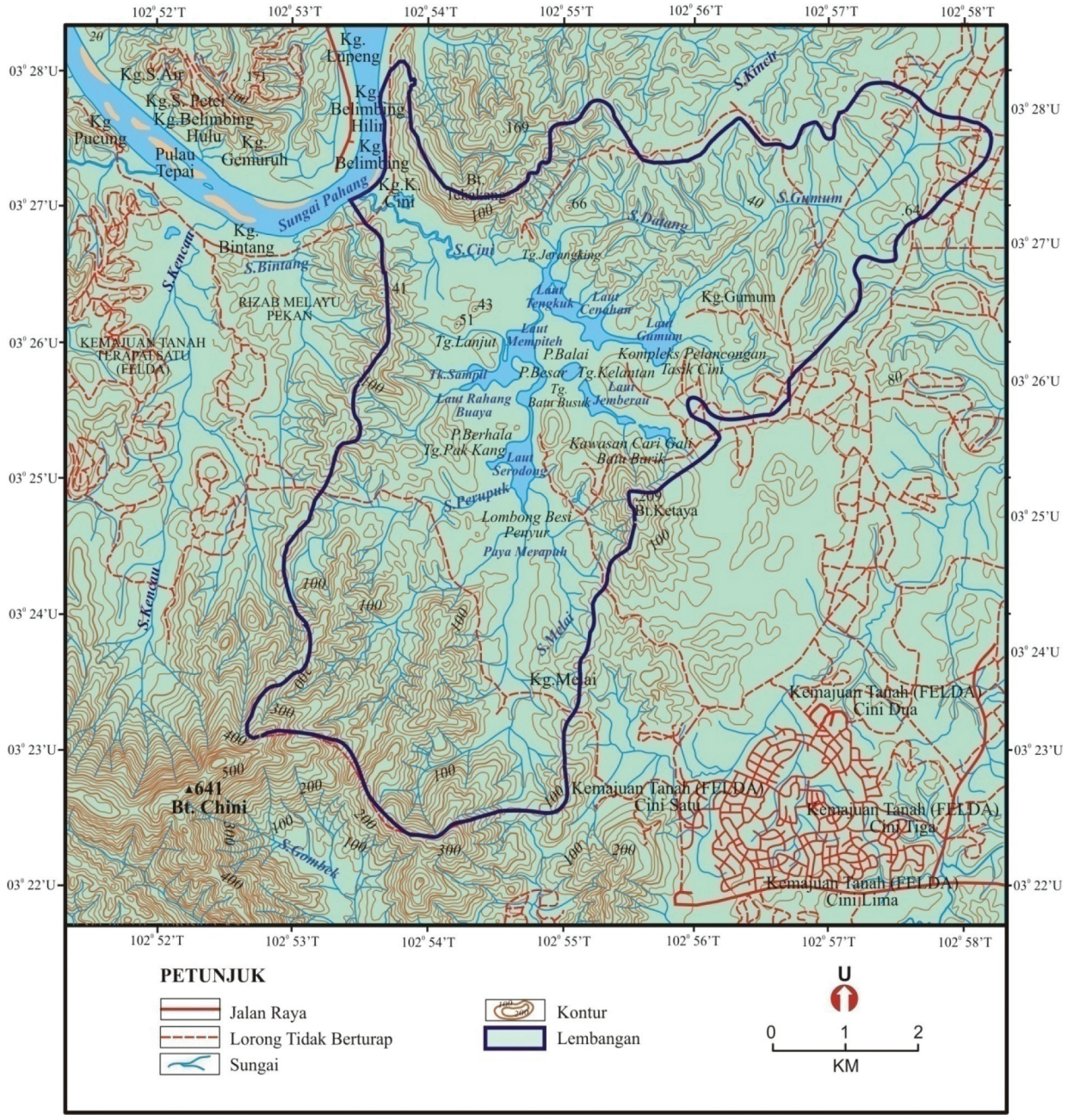

FIGURE 1. Chini watershed forest, Pekan, Pahang

Satellite image of SPOT 5 (2007) has been used to determine the forest types at Chini watershed. The unsupervised and supervised classifications were used to distinguish the area of forest types based on the distance from the water bodies (Harris 1987; Heywood et al. 1998). Based on the analysis, we concluded that there were three types of forests that are inland, seasonal flood (lakeside) and riverine forest. Stratified sampling method was used to build the study plots at these three forest types. Thirty plots with a total sampling area of 3.0 ha at the dimension of 50 m × 20 m each was established (Figure 2). Fourteen plots were established at inland forest, nine plots at seasonal flood forest and seven plots at riverine forest. All trees with diameter at breast height (dbh) of 5 cm and above were measured, identified, and voucher samples were made. The above ground biomass of trees in the study plots was estimated using the regression formula proposed by Kato et al. (1978) that was developed from the data that they gathered in a study using destructive sampling methods at the Pasoh Forest Reserve, a lowland dipterocarp forest. The formula uses tree diameter to calculate basal area (*BA*), tree height (*H*), the biomass of stem (W_s), branches (W_b) and leaves (W_l).

To express the structure of a plant community, several characteristics were taken into consideration including species composition, species diversity and relative abundances. Parameters used to determine species abundances were density, dominance, frequency, and

importance value index (IV_i) at species and family level (Brower et al. 1997). Species diversity considers both the number of species in a defined sampling unit (species richness) and the distribution of individuals among species (species evenness) to show relative abundance of the species. In this study, species diversity was measured using Shannon-Weiner Index of diversity. The advantage of using this index is that individuals are randomly sampled from an indefinitely large population and it assumes that all species are represented in the sample (Magurran 1988). Margalef richness and Shannon evenness indices were also calculated following Magurran (1988). The Sorenson's community similarity index was also analyzed to measure the degree of species similarity between the three types of forest using the PCORD version 5 software (Mc Cune & Grace 2002).

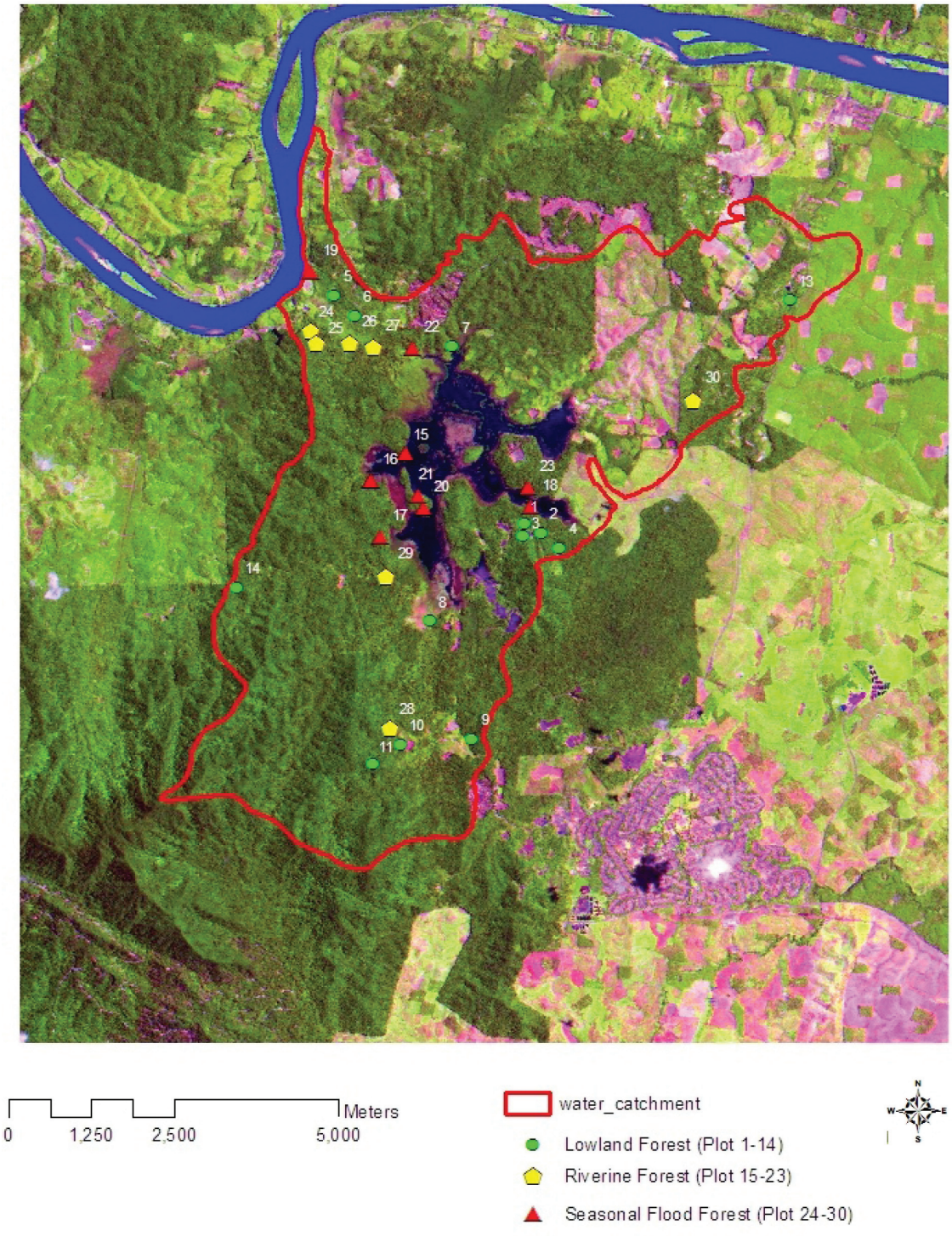

FIGURE 2. Thirty sampling plots at Chini watershed forest, Pekan, Pahang

RESULTS AND DISCUSSION

TAXONOMIC COMPOSITION

The study recorded a total of 3974 trees of 583 species from 226 genera and 65 families. A total of 2061 individuals of 393 species from 164 genera and 57 families were recorded in the inland forest. In the seasonal flood forest, a total of 1019 individuals of 268 species from 137 genera and 57 families while in the riverine forest, a total of 894 individuals of 260 species from 133 genera and 53 families were recorded (Tables 1 and 2). In terms of stand density, a total of 1472 ind./ha were recorded in the inland forest, 1132 ind./ha in the seasonal flood forest and 1277 ind./ha in the riverine forests. The results showed that inland forest has the highest density of trees compared to the other forests. Euphorbiaceae had the highest density in the inland and riverine forest with 266 ind./ha and 197 ind./ha respectively while Myrtaceae had the highest density in the seasonal flood forest with 168 ind./ha (Table 3). This result was similar to Raffae (2003), Norwahidah (2005) and Nurhashimah (2008) where Euphorbiaceae had the highest density in the inland forest. Euphorbiaceae was also reported as the family with the highest density in the riverine forest by Foo (2005) at Kenong Forest Park, Norsiah (2004) at Sg. Chini, Tasik Chini and Siti Najmi (2005) at Sungai Jemberau, Tasik Chini.

TABLE 1. Species composition of three types of forest at Chini watershed, Pahang

Area	Size	Family	Genera	Species	Ind.	Ind./ha
Inland	1.4 ha	57	164	393	2061	1472
Seasonal flood	0.9 ha	57	137	268	1019	1132
Riverine	0.7 ha	53	133	260	894	1277

TABLE 2. List of taxonomic composition in the three types of forests at Chini watershed, Pekan, Pahang
The families based on Turner (1995)

Family	Inland			Seasonal Flood			Riparian		
	Genera	Species	Ind.	Genera	Species	Ind.	Genera	Species	Ind.
Aceraceae	nil	nil	nil	nil	nil	nil	1	1	1
Alangiaceae	1	2	3	1	2	3	1	2	5
Anacardiaceae	7	10	65	9	12	42	6	9	26
Anisophylleaceae	1	1	3	1	1	2	nil	nil	nil
Annonaceae	13	24	89	5	12	22	8	13	56
Apocynaceae	4	3	31	1	1	1	nil	nil	nil
Aquifoliaceae	nil	nil	nil	nil	nil	nil	1	1	1
Bombacaceae	1	2	9	1	1	8	1	1	1
Burseraceae	3	16	114	4	8	39	3	10	30
Celastraceae	3	3	8	3	3	14	1	3	5
Chrysobalanaceae	2	2	3	4	5	12	1	1	2
Combretaceae	1	1	1	1	1	1	1	1	1
Connaraceae	1	1	3	1	1	18	nil	nil	nil
Crypteroniaceae	nil	nil	nil	nil	nil	nil	1	2	2
Ctenolophaceae	nil	nil	nil	1	1	1	1	1	1
Dilleniaceae	1	4	9	1	1	3	1	3	17
Dipterocarpaceae	5	28	143	4	10	70	1	10	56
Ebenaceae	1	13	36	1	4	9	4	5	6
Elaeocarpaceae	1	5	15	2	5	6	1	3	9
Erythroxylaceae	1	1	3	nil	nil	nil	1	1	1
Euphorbiaceae	15	41	372	9	24	93	12	30	138
Fagaceae	2	5	50	2	3	4	2	3	9
Flacourtiaceae	3	5	20	3	4	7	2	7	14
Gnetaceae	nil	nil	nil	1	1	3	4	1	1
Guttiferae	3	17	42	4	16	72	1	10	27
Icacinaceae	2	2	3	2	2	5	3	2	3
Irvingaceae	1	1	1	1	1	1	nil	nil	nil
Ixonanthaceae	1	1	15	1	1	7	2	1	11
Lauraceae	7	18	32	8	15	41	1	15	43
Lecythidaceae	1	4	23	1	1	1	8	2	14
Leguminosae	8	11	77	9	15	63	1	8	57

(continue)

Continued (TABLE 2)

Family	Inland			Seasonal Flood			Riparian		
	Genera	Species	Ind.	Genera	Species	Ind.	Genera	Species	Ind.
Loganiaceae	1	1	8	1	1	1	7	1	4
Lythraceae	nil	nil	nil	nil	nil	nil	1	1	1
Melastomataceae	3	7	24	2	9	18	1	6	34
Meliaceae	6	13	25	3	3	7	3	10	31
Moraceae	3	13	66	3	8	49	4	7	15
Myristicaceae	4	18	78	3	7	13	2	8	29
Myrsinaceae	2	4	11	1	3	5	3	1	1
Myrtaceae	2	19	103	3	26	151	1	13	43
Ochnaceae	2	2	10	2	2	10	nil	nil	nil
Olacaceae	3	3	28	2	2	4	2	2	9
Opiliaceae	nil	nil	nil	1	1	10	2	1	2
Oxalidaceae	1	4	45	1	4	27	1	2	3
Pandaceae	1	1	1	2	2	5	1	1	3
Passifloraceae	1	1	8	1	1	5	nil	nil	nil
Polygalaceae	1	5	23	1	5	17	1	3	14
Proteaceae	nil	nil	nil	1	1	1	1	1	2
Rhizophoraceae	1	3	26	1	1	2	1	2	5
Rosaceae	1	3	6	nil	nil	nil	2	1	2
Rubiaceae	11	13	130	4	4	10	1	10	16
Rutaceae	2	5	18	nil	nil	nil	7	2	3
Santalaceae	1	1	2	nil	nil	nil	nil	nil	nil
Sapindaceae	4	5	26	4	6	22	2	7	12
Sapotaceae	4	11	44	4	6	11	5	7	31
Simaroubaceae	1	1	2	1	1	3	nil	nil	nil
Stenolophaceae	1	1	1	1	1	3	nil	nil	nil
Sterculiaceae	4	9	35	3	5	12	5	6	12
Styracaceae	1	1	5	1	1	2	nil	nil	nil
Symplocaceae	1	1	2	1	1	2	3	1	1
Theaceae	2	2	8	1	2	14	1	3	13
Thymelaeaceae	2	3	5	2	3	7	nil	nil	nil
Tiliaceae	4	11	66	2	6	18	2	12	47
Trigoniaceae	1	1	1	1	1	1	nil	nil	nil
Ulmaceae	1	4	36	1	2	19	1	2	6
Verbenaceae	3	6	48	2	2	22	3	4	18
Total	164	393	2061	137	268	1019	133	260	894

TABLE 3. Family with the highest density in the three types of forest in Chini watershed, Pahang

Area	Family	Ind.	Ind./ha
Inland	Euphorbiaceae	372	266
Seasonal flood	Myrtaceae	151	168
Riverine	Euphorbiaceae	138	197

FOREST STRUCTURE

Endospermum diadenum (Euphorbiaceae) was the most important species in the inland forest with the Importance Value Index (SIV_i) at 3.36%. In the riverine forest, *Ganua motleyana* (Sapotaceae) was the most important species with the SIV_i at 2.35% while in the seasonal flood forest, *Streblus elongatus* (Moarceae) was the most important species with the SIV_i at 4.43%. Euphorbiaceae was the most important family in the inland and riverine forest with FIV_i at 14.25% and 12.91% respectively. Meanwhile, Myrtaceae was the most important family in the seasonal flood forest with FIV_i at 12.36% (Table 4). These results were similar with Foo (2005), Siti Najmi (2005), Nurhashimah (2008) and Norwahidah (2008) where Euphorbiaceae was the most important family in the inland forest at their study sites. According to Curtis and Macintosh (1951), a species with SIV_i of more than 10% and family with FIV_i of more than 40% can be considered as the dominant species or

TABLE 4. Dominant species and family based on importance value index (IV_i) in the three types of forests at Chini watershed, Pahang

	Inland forest	Riverine forest	Seasonal flood forest
Species	*Endospermum diadenum* (Euphorbiaceae)	*Ganua motleyana* (Sapotaceae)	*Streblus elongatus* (Moraceae)
Family	Euphorbiaceae	Euphorbiaceae	Myrtaceae

family, respectively in a particular community. Therefore, there are no dominant species or family identified in these three types of forests.

SPECIES DIVERSITY

The Shannon-Weiner Diversity Index (H') calculated using the BIODAP software for the inland forest was 5.40, whereas in the riverine forest was 5.08 and in the seasonal flood forest was 5.10 (Table 5). According to Magurran (1988), the value of the H' usually lies between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5. Therefore, the values of the diversity index in the three types of forests were considered exceptionally high. It showed that the species at these three types of forests were highly diverse. In addition, the values of H' at the three types of forest was considered high compared to previous studies at riverine and inland forests in Pahang (Table 6). Based on the Shannon Evenness Index (J'), the result showed that the three types of forest have the value of 0.9. Referring to Magurran (1988), J' with 1.00 representing a situation in which all species are equally abundant. Margalef Richness Index (R') revealed that the tree species richness in the riverine was 38.11, seasonal flood forest was 38.55 which, were lower than the inland forest at 52.94. According to Brower et al. (1997), richness can be expressed simply as the number of species.

ABOVE GROUND BIOMASS

The total above ground biomass of trees at dbh 5 cm and above in the inland plot was estimated at 366.2 t/ha. In the seasonal flood plot the value was estimated at 379.1 t/ha whilst in the riverine plot, the value was estimated at 401.8 t/ha. It is apparent that the total biomass in the seasonal flood and riverine forest were higher than the inland forest. Eventhough the riverine and seasonal flood forests has less number of trees than the inland forest, they have relatively bigger trees, with mean dbh of 13.89 ± 6.96 and 14.33 ± 7.16 cm, respectively, than the lowland forests of 13.28 ± 6.04 cm ($P < 0.05$). This result was similar to previous studies by Foo (2005) and Norwahidah (2005) where they also found that the above ground biomass of riverine forest was relatively higher than the inland forest. Factors such as trees size and forest gap influenced the values of forest above ground biomass (Raffae 2003; Fakhrul Hatta 2005; Rohani 2008). Based on Mushrifah et al. (2005), the inland forest in Chini watershed has been disturbed by activities of logging and mining. This may influence the sizes of the trees in the inland forest that were subjected to logging impact.

COMMUNITY SIMILARITY

Similarity coefficients were used to measure the similarity of species between two sites and these indices are designed

TABLE 5. Species diversity indices values for the three types of forests at Chini watershed

Indices	Inland	Seasonal flood	Riverine
Shannon-Weiner Diversity Index, *H'*	5.40	5.10	5.08
Shannon Evenness Index, *J'*	0.90	0.91	0.91
Margalef Richness Index, *R'*	52.94	38.55	38.11

TABLE 6. Comparison of Shannon-Weiner Diversity Index between this study and other similar studies in Pahang

	Inland	Seasonal Flood	Riverine
Chini watershed (This study)	5.40	5.08	5.10
Sg. Chini (Norwahidah 2005)	4.54	nil	3.99
Sg. Jemberau (Siti Najmi 2005)	3.98	nil	3.98
Sg. Kenong (Foo 2005)	4.23	nil	4.12
Bukit Tebakang (Fajariah 2004)	4.58	nil	nil
Sg. Chini (Norsiah 2004)	nil	nil	4.19

equal to 1.0 in cases of complete similarity. Sorenson's community similarity index values (CCs) calculated for the three types of forest are presented in Table 7. Results indicated that the tree species communities of the three types of forests were low in similarity. All three types of forest have only 40% of the tree species similarity. The hierarchical cluster (Figure 3) showed that the plots were clustered into three main communities based on their species occurrence. About 75-85% of species similarity clustered the plots into three big groups which, group 1 was dominated by species from the inland forest; group 2 was dominated by species of seasonal flood forest, while group 3 was dominated by species from the riverine forest. From the dendogram, there were certain plots from different types of forests were clustered together within the main three groups identified because they shared some species from other forest types in their community.

TABLE 6. The Sorenson coefficient values of three types of forests at Chini watershed

Plot	Inland	Seasonal flood
Seasonal flood	0.446	
Riverine	0.422	0.460

ENDEMISM AND CONSERVATION STATUS

From the total of 583 species in the three types of forests, 44 species were identified as endemic species (Table 8). Ng et al. (1991) stated that there are 2,830 tree species found in Peninsular Malaysia and the number of endemic trees total are 746 species that represents 26.4% of the total number of tree species. Therefore, the endemic species in this study plot represented 5.9% of endemic trees in Peninsular Malaysia. In the inland plot, 29 species from the total of 393 species identified were endemic and this represented 3.89% of endemic trees in Peninsular Malaysia. In the seasonal flood forest, 14 species from a total of 268 species were endemic in Peninsular Malaysia (1.88%) while in the riverine plot, 18 species from the total of 260 species recorded in this study were endemic (2.41%).

A total of 104 species in the study area were found to be listed in 2009 IUCN Red List Categories of WCMC. These species were threatened and rated in four different categories that are low risk, vulnerable, endangered and critically endangered. Based on Table 9, a total of 8 species were listed as vulnerable, 2 species as data deficient, 70 species as lower risk, 12 species as endangered and another 12 species as critically endangered. All the endangered and critically endangered species listed were from the

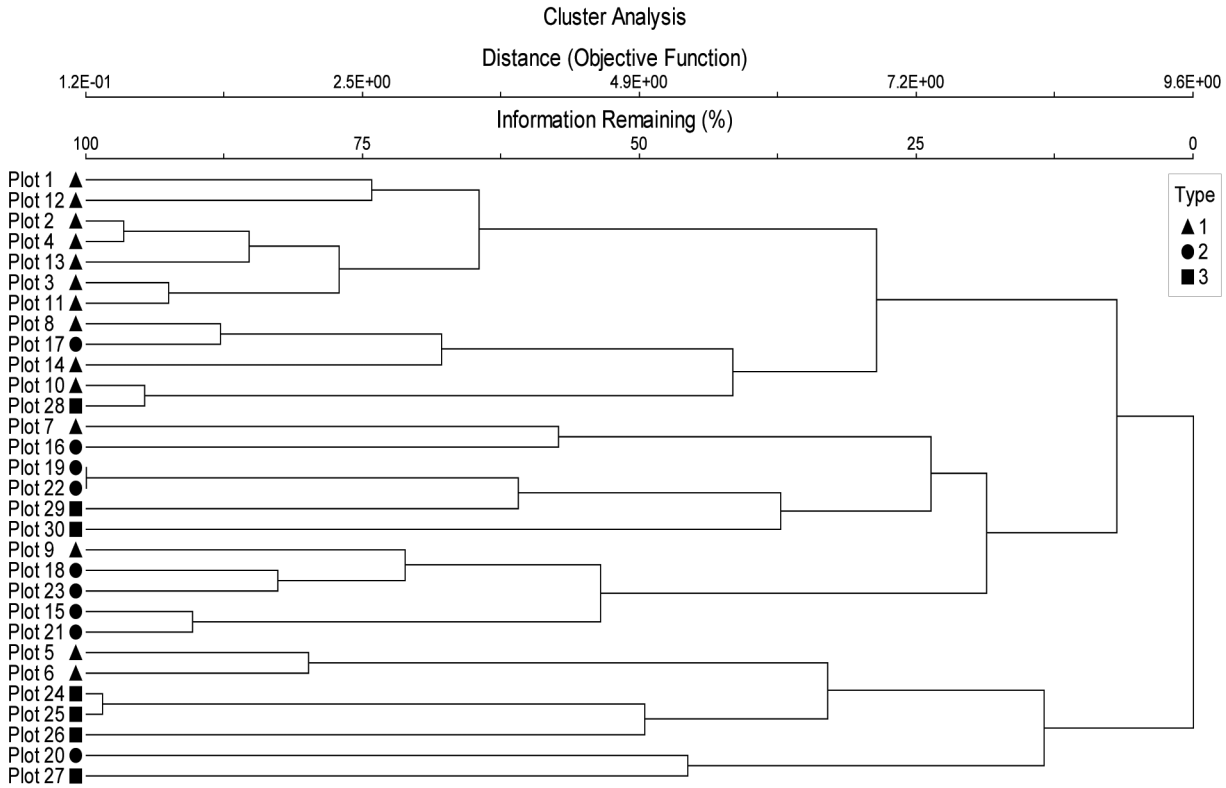

FIGURE 3. Cluster dendogram of the three types of forests at Chini watershed, Pahang using Sorenson Bray Curtis and Flexible Beta Method (Inland plots: Type 1, seasonal flood plots: Type 2, riverine plots: Type 3)

TABLE 8. Endemic species in Peninsular Malaysia that were found in Chini watershed forests, Pahang

Family	Species	Locations
Anacardiaceae	*Gluta curtisii* (Oliv.) Ding Hou	Ked, Ktan, Pen, Prk, Pah, Sel, Joh
Annonaceae	*Alphonsea maingayi* Hook.*f.* & Thomson	Prk, Sel, NS, Mal, Joh, Spore
Annonaceae	*Cyathocalyx scortechinii* (King) J. Sinclair	Prk, Pah
Annonaceae	*Cyathocalyx scortechinii* (King) J. Sinclair	Ktan, Tganu, Prk, Pah, Sel, Mal, Joh
Annonaceae	*Enicosanthum fuscum* (King) Airy Shaw	Prk, Pah
Annonaceae	*Popowia fusca* King	Prk, Pah, Spore
Annonaceae	*Xylopia magna* Maingay *ex* Hook.*f.* & Thomson	Ked, Ktan, Tganu, Prk, Pah, Sel, NS, Mal, Spore
Burseraceae	*Dacryodes kingii* (Engl.) Kalkman	Peninsular Malaysia
Burseraceae	*Dacryodes puberula* (Benn.) H.J. Lam	Prk, Pah, NS, Mal
Dipterocarpaceae	*Hopea pubescens* Ridl.	Ktan, Pah
Dipterocarpaceae	*Vatica bella* Slooten	Pk and Ph southward
Ebenaceae	*Diospyros adenophora* Bakh.	Ktan, Pah, NS
Ebenaceae	*Diospyros ismailii* Ng	Ked, Tganu, Pah, Sel, NS, Joh
Ebenaceae	*Diospyros nutans* King & Gamble	Ktan, Prk, Pah, Sel, NS, Mal, Joh
Ebenaceae	*Diospyros scortechinii* King & Gamble	Ktan, Tganu, Prk, Pah, NS
Euphorbiaceae	*Aporusa whitmorei* Airy Shaw	Pah
Euphorbiaceae	*Aporusa nervosa* Hook.*f.*	Peninsular Malaysia
Euphorbiaceae	*Cleistanthus maingayi* Hook.*f.*	Sel, NS, Mal, Joh
Euphorbiaceae	*Croton erythrostachys* Hook.*f.*,	Tganu, Prk, Pah, Sel, NS, Mal, Joh
Euphorbiaceae	*Macaranga amissa* Airy Shaw	Tganu, Prk, Mal, Joh
Euphorbiaceae	*Mallotus penangensis* Müll.Arg.	Peninsular Malaysia
Fagaceae	*Lithocarpus curtisii* (King *ex* Hook.*f.*) A. Camus	Pen, Ktan, Tganu, Prk, Pah, Sel
Flacourtiaceae	*Casearia clarkei* King var. *clarkei*	Pen, Prk, Sel, Mal, Spore
Flacourtiaceae	*Casearia clarkei* King var. *kunstleri* (King) Ridl.	Prk, Pah, Sel, Joh
Flacourtiaceae	*Scaphocalyx spathacea* Ridl.	Ktan, Pah, Sel, NS, Mal, Joh
Guttiferae	*Garcinia opaca* King var. *dumosa* Whitmore	Prk, Pah, Sel, Joh
Lauraceae	*Actinodaphne pruinosa* Nees	Ked, Pen, Sel, NS, Mal, Spore
Lauraceae	*Beilschmiedia pahangensis* Gamble	Ktan, Prk, Pah
Lauraceae	*Cinnamomum mollissimum* Hook.*f.*	Pen, Ktan, Tganu, Prk, Pah, Sel, NS, Mal, Joh
Lauraceae	*Endiandra maingayi* Hook.*f.*	Ktan, Prk, Pah, Sel, NS, Joh
Myrtaceae	*Syzygium nemestrinum* (M.R. Hend.) I.M. Turner	Tganu, Pah, Spore
Polygalaceae	*Xanthophyllum cockburnii* Meijden	Joh & Pah
Rhizophoraceae	*Pellacalyx saccardianus* Scort.	Peninsular Malaysia
Rubiaceae	*Psydrax maingayi* (Hook.*f.*) Bridson	Tganu, Pah, Prk, Sel, NS, Mal, Joh
Rubiaceae	*Rothmannia malayana* K.M. Wong	Ktan & Pah
Sapindaceae	*Nephelium costatum* Hiern	Prk, Pah, Sel, NS, Mal
Sapotaceae	*Palaquium maingayi* (C.B. Clarke) King & Gamble	Ked, Ktan, Prk, Pah, Sel, NS, Mal, Joh
Theaceae	*Gordonia multinervis* King	Pen, Ktan, Tganu, Prk, Pah, Mal, Joh, Spore
Theaceae	*Gordonia singaporiana* Wall. *ex* Ridl.	Pen, Prk, Pah, NS, Mal, Joh, Spore
Tiliaceae	*Pentace microlepidota* Kosterm	Ktan, Prk, Pah, Sel
Tiliaceae	*Pentace strychnoidea* King	Ked, Ktan, Tganu, Prk, Pah, Sel, NS
Tiliaceae	*Schoutenia furfuracea* Kochummen	Joh & Pah
Verbenaceae	*Callicarpa maingayi* King & Gamble	Peninsular Malaysia

Notes: Ked=Kedah, Pah=Pahang, Ktan=Kelantan, Tgganu= Terengganu, Sel= Selangor, Prk= Perak, Pen= Penang, NS= Negeri Sembilan, Mal= Malacca, Joh= Johore, Spore= Singapore

Dipterocarpaceae family. The number of endemic and threatened species was high in this study area, which indicated that Chini watershed deserves more attention in conservation efforts.

CONCLUSION

The floristic variation of the three forest types indicate that proper management and conservation of this area is important in ensuring the ecological functions are intact

TABLE 9. The conservation status of tree species in the 3 ha study plot based on the 2009 IUCN Red List of Threatened Species

No.	Family	Species	Conservation Status
1	Lauraceae	*Actinodaphne pruinosa* Nees	LR/lc
2	Meliaceae	*Aglaia elliptica* Blume	LR/lc
3	Meliaceae	*Aglaia forbesii* King	LR/lc
4	Meliaceae	*Aglaia hiernii* King	LR/lc
5	Meliaceae	*Aglaia macrocarpa* (Miq.) Pannel	LR/lc
6	Meliaceae	*Aglaia odoratissima* Blume	LR/lc
7	Meliaceae	*Aglaia rubiginosa* (Hiern) Pannell	LR/lc
8	Meliaceae	*Aglaia tomentosa* Teijsm. & Binn.	LR/lc
9	Alangiaceae	*Alangium nobile* (C.B. Clarke) Harms	LR/lc
10	Annonaceae	*Alphonsea maingayi* Hook.f. & Thomson	LR/lc
11	Anisophylleaceae	*Anisophyllea corneri* Ding Hou	LR/lc
12	Dipterocarpaceae	*Anisoptera costata* Korth.	ER A1cd+2cd
13	Dipterocarpaceae	*Anisoptera curtisii* Dyer ex King	CR A1cd+2cd
14	Dipterocarpaceae	*Anisoptera laevis* Ridl.	ER A1cd+2cd
15	Thymelaeaceae	*Aquilaria malaccensis* Lam.	VU A1cd
16	Lauraceae	*Beilschmiedia pahangensis* Gamble	LR/lc
17	Celastraceae	*Bhesa paniculata* Arn.	LR/lc
18	Ochnaceae	*Brackenridgea hookeri* (Planch.) A. Gray	LR/lc
19	Verbenaceae	*Callicarpa maingayi* King & Gamble	LR/lc
20	Burseraceae	*Canarium littorale* Blume	LR/lc
21	Burseraceae	*Canarium patentinervium* Miq.	LR/lc
22	Burseraceae	*Dacryodes costata* (Benn.) Lam.	LR/lc
23	Burseraceae	*Dacryodes kingii* (Engl.) Kalkman	LR/lc dependent
24	Burseraceae	*Dacryodes puberula* (Benn.) H.J. Lam.	VU B1+2a
25	Burseraceae	*Dacryodes rostrata* (Blume) H.J. Lam.	LR/lc
26	Ebenaceae	*Diospyros adenophora* Bakh.	LR/lc
27	Ebenaceae	*Diospyros apiculata* Hiern.	LR/lc
28	Ebenaceae	*Diospyros ismailii* Ng	LR/lc
29	Ebenaceae	*Diospyros latisepala* Ridl.	LR/lc
30	Ebenaceae	*Diospyros nutans* King & Gamble	LR/lc
31	Ebenaceae	*Diospyros scortechinii* King & Gamble	LR/lc
32	Dipterocarpaceae	*Dipterocarpus baudii* Korth.	CR
33	Dipterocarpaceae	*Dipterocarpus cornutus* Dyer	CR
34	Dipterocarpaceae	*Dipterocarpus costatus* Gaertn.f.	ER
35	Dipterocarpaceae	*Dipterocarpus costulatus* Slooten.	CR
36	Dipterocarpaceae	*Dipterocarpus crinitus* Dyer	ER
37	Dipterocarpaceae	*Dipterocarpus grandiflorus* (Blanco) Blanco	CR
38	Dipterocarpaceae	D*ipterocarpus kunstleri* King	CR
39	Dipterocarpaceae	*Dipterocarpus oblongifolius* Blume	LR/lc
40	Dipterocarpaceae	*Dipterocarpus sublamellatus* Foxw.	ER A1cd+2cd
41	Apocynaceae	*Dyera costulata* (Miq.) Hook.f.	LR/lc
42	Lauraceae	*Endiandra maingayi* Hook.f.	LR/lc
43	Annonaceae	*Enicosanthum congregatum* (King) Airy Shaw	LR/cd
44	Annonaceae	*Enicosanthum fuscum* (King) Airy Shaw	LR/nt
45	Celastraceae	*Euonymus javanicus* Blume	LR/lc
46	Gittiferae	*Garcinia opaca* King var. opaca	LR/lc
47	Guttiferae	*Garcinia scortechinii* King	LR/lc
48	Anacardiaceae	*Gluta curtisii* (Oliv.) Ding Hou	LR/lc
49	Ochnaceae	*Campylospermum serratum* (Gaertn.) Bittrich & M.C.E. Amaral	LR/lc
51	Dipterocarpaceae	*Hopea mengerawan* Miq.	CR
52	Dipterocarpaceae	*Hopea pubescens* Ridl.	CR
53	Dipterocarpaceae	*Hopea sangal* Korth.	CR
54	Myristicaceae	*Horsfieldia fulva* (King) Warb.	VU
55	Myristicaceae	*Horsfieldia irya* (Gaertn.) Warb.	LR/lc

(continue)

Continued (TABLE 9)

No.	Family	Species	Conservation Status
56	Myristicaceae	*Horsfieldia sparsa* W.J. de Wilde.	LR/nt
57	Myristicaceae	*Horsfieldia superba* (Hook.f. & Thomson) Warb.	LR/nt
58	Myristicaceae	*Horsfieldia tomentosa* Warb.	LR/nt
59	Myristicaceae	*Horsfieldia wallichii* (Hook.f. & Thomson) Warb.	LR/lc
60	Irvingaceae	*Irvingia malayana* Oliv. ex Benn.	LR/lc
61	Myristicaceae	*Knema conferta* (King) Warb.	LR/lc
62	Myristicaceae	*Knema furfuracea* (Hook.f. & Thomson) Warb.	LR/lc
63	Myristicaceae	*Knema intermedia* (Blume) Warb.	LR/nt
64	Myristicaceae	*Knema scortechinii* (King) J. Sinclair	LR/lc
65	Leguminosae	*Koompassia malaccensis* Maing. ex Benth.	LR/cd
66	Chrysobalanaceae	*Licania splendens* (Korth.) Prance	LR/lc
67	Fagaceae	*Lithocarpus curtisii* (King ex Hook.f.) A. Camus	VU
68	Celastraceae	*Lophopetalum javanicum* (Zoll.) Turcz.	LR/lc
69	Anacardiaceae	*Mangifera foetida* Lour.	LR/lc
70	Tiliaceae	*Microcos laurifolia* (Hook. ex Mast.) Burret	LR/cd
71	Myristicaceae	*Myristica cinnamomea* King	LR/lc
72	Myristicaceae	*Myristica maingayi* Hook.f.	LR/nt
73	Sapindaceae	*Nephelium costatum* Hiern.	VU
74	Olacaceae	*Ochanostachys amentacea* Mast.	DD
75	Sapotaceae	*Palaquium maingayi* (C.B. Clarke) King & Gamble	LR/lc
76	Chrysobalanaceae	*Parastemon urophyllus* (Wall. ex A.DC.) A.DC.	LR/lc
77	Chrysobalanaceae	*Parinari costata* (Korth.) Blume ssp. polyneura (Miq.) Prance	LR/lc
78	Rhizophoraceae	*Pellacalyx saccardianus* Scort.	LR/lc
79	Tiliaceae	*Pentace microlepidota* Kosterm.	VU
80	Anacardiaceae	*Pentaspadon motleyi* Hook.f.	DD
81	Annonaceae	*Popowia fusca* King	LR/lc
82	Rosaceae	*Prunus arborea* (Blume) Kalkman var. arborea	LR/lc
83	Rosaceae	*Prunus grisea* (Blume) Kalkman var. tomentosa (Koord. & Valeton) Kalkman	LR/lc
84	Rosaceae	*Prunus polystachya* (Hook.f.) Kalkman	LR/lc
85	Burseraceae	*Santiria apiculata* Benn.	LR/lc
86	Burseraceae	*Santiria griffithii* (Hook.f.) Engl.	LR/lc
87	Burseraceae	*Santiria laevigata* Blume	LR/lc
88	Burseraceae	*Santiria tomentosa* Blume	LR/lc
89	Tiliaceae	*Schoutenia furfuracea* Kochummen	LR/cd
90	Santalaceae	*Scleropyrum wallichianum* (Wight & Arn.) Arn.	LR/lc
91	Burseraceae	*Scutinanthe brunnea* Thwaites	LR/lc
92	Dipterocarpaceae	*Shorea acuminata* Dyer	CR
93	Dipterocarpaceae	*Shorea balanocarpoides* Symington	ER
94	Dipterocarpaceae	*Shorea leprosula* Miq.	ER
95	Dipterocarpaceae	*Shorea maxwelliana* King	ER
96	Dipterocarpaceae	*Shorea ovata Dyer* ex Brandis	ER
97	Dipterocarpaceae	*Shorea pauciflora* King	ER
98	Myrtaceae	*Shorea ovata Dyer* ex Brandis	VU
99	Dipterocarpaceae	*Vatica bella* Slooten	CR
100	Dipterocarpaceae	*Vatica maingayi* Dyer	CR
101	Dipterocarpaceae	*Vatica nitens* King	ER
102	Dipterocarpaceae	*Vatica pauciflora* (Korth.) Blume	ER
103	Apocynaceae	*Wrightia laevis* Hook.f. ssp. laevis	LR/lc
104	Annonaceae	*Xylopia magna* Maingay ex Hook.f. & Thomson	LR/lc

*Notes: VU/lc = Vulnerable/least concern, VU/lc = Vulnerable/conservation dependent, ER= Endangered, CR= critically endangered, DD= Data Deficient

in this degraded wetland ecosystem. The high number of endemism and threatened species at Chini watershed forests also reveal that this site deserves more attention from related authorities and stakeholders as there is a high probability that the forests are supporting many other important plant species. Immediate conservation actions should be taken to let the preservation of many other biotas in Chini watershed, Pekan, Pahang.

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