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(POPULASI CACING PADA LAHAN BEKAS TAMBANG BATUBARA DI KALIMANTAN TIMUR, INDONESIA)

Aktivitas pertambangan batubara di Indonesia telah menyebabkan kerusakan tanah yang parah dan menurunkan tingkat populasi cacing tanah. Penelitian ini bertujuan untuk mempelajari populasi cacing tanah di berbagai umur tanaman rehabilitasi pada lahan bekas tambang batubara, di PT. Kideco Jaya Agung, Kalimantan Timur. Pada penelitian ini, untuk mengetahui populasi cacing dilakukan dengan mengambil sampel tanah pada lahan rehabilitasi dengan umur tanaman 2, 4, 6, 8, dan 10 tahun, sebanyak 5 sampel setiap tingkatan umur dengan ukuran 30cm x 30cm, kedalaman 20cm. Jarak antar sampel 20m. Ketebalan serasah juga diukur pada setiap sampel yang diambil. Analisis chi square dilakukan untuk mengetahui tingkat signifikansi kerapatan cacing pada setiap tingkatan umur tanaman rehabilitasi, sedangkan analisis korelasi dilakukan untuk mengetahui hubungan jumlah cacing dengan ketebalan seresah. Hasil penelitian menunjukkan bahwa hanya ditemukan 2 jenis cacing tanah dari semua lahan rehabilitasi, dimana jumlah populasi meningkat pada tiap tingkatan umur tanaman rehabilitasi. Namun demikian, populasi cacing pada lahan rehabilitasi dengan umur tanaman 10 tahun hampir sama dengan jumlah populasi cacing tanah pada hutan alam. Secara umum, penanaman pohon yang menghasilkan banyak serasah mampu menstimulasi peningkatan populasi cacing tanah dan menginisiasi suksesi. Selain itu, diperlukan waktu lebih dari 10 tahun bagi lahan bekas tambang batubara agar kerapatan cacing tanah kembali, seperti semula setelah dilakukan rehabilitasi.

Kata kunci: Tambang batubara, cacing tanah, serasah, rehabilitasi

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S.K. Sharma, S.R. Shukla and M. Sujatha

PHYSICAL AND MECHANICAL EVALUATION OF 8-YEARS-OLD ACACIA HYBRID (*Acacia mangium* x *A. auriculiformis*) CLONES FOR VARIOUS END USES

(EVALUASI SIFAT FISIK DAN MEKANIK KLON ACACIA HIBRID BERUMUR 8 TAHUN (Acacia mangium × A. auriculiformis) UNTUK BERBAGAI PENGGUNAAN AKHIR)

Saat ini, pemanfaatan klon tanaman hutan merupakan hal penting karena variasi kualitas kayu yang bervariasi berdasarkan karakteristik kayu yang berbeda. Pohon hibrida dari hutan klon perlu dicirikan kualitas kayunya untuk menemukan yang terbaik dan sesuai penggunaannya. Untuk itu, tiga klon (HD3, K47, H4) dari akasia hibrida umur 8 tahun (*Acacia mangium × A. auriculiformis*) dievaluasi sebagai bentuk perbandingan antar klon terkait kualitas kayunya dengan mengevaluasi sifat fisik dan mekanik yang sesuai dengan Standar India. Contoh uji setinggi dada (dbh) dari ketiga klon dipelajari diameter batangnya, kandungan kayu teras, dan sifat fisik dan mekaniknya. Dbh dari ketiga klon itu sekitar 30-35% dan 60-70% lebih besar daripada bentuk murni *Acacia auriculiformis* dan *A. mangium* pada usia yang sama. Penyusutan volumetrik dari ketiga klon itu bervariasi dari 7,8 hingga 8,6%. Nilai penyusutan yang rendah dapat dikaitkan dengan stabilitas dimensi yang lebih tinggi dari klon kayu tersebut. Data yang diperoleh dalam kondisi segar dan kering udara digunakan untuk menghitung indeks kesesuaian mengacu pada kayu jati (*Tectona grandis*) yang diambil sebagai kayu referensi di India. Semua indeks

kesesuaian dari klon ini dapat dibandingkan atau sedikit lebih rendah dari bentuk murni *Acacia auriculiformis* dan *A. mangium*. Tidak banyak variasi antar-klon yang diamati di sebagian besar indeks kesesuaian, walaupun ketiga klon tersebut secara eksklusif ditanam untuk industri pulp dan kertas, tetapi sifat-sifat kesesuaian secara komparatif untuk penggunaan akhir yang berbeda menunjukkan bahwa klon ini juga dapat digunakan untuk penggunaan non-struktural tertentu seperti gagang perkakas, kotak kemasan ringan, palet, dan perabotan ringan.

Kata kunci: Akasia hibrida, klon, kualitas kayu, sifat mekanis, angka kesesuaian

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Ja Posman Napitu, Aceng Hidayat, Sambas Basuni and Sofyan Sjaf

CONFLICT RESOLUTION CONCEPT: IMPLEMENTATION OF CCA-FM MODEL IN MERANTI FOREST MANAGEMENT UNIT, SOUTH SUMATRA

(KONSEP RESOLUSI KONFLIK: IMPLEMENTASI MODEL CCA-FM DI KESATUAN PENGELOLAAN HUTAN PRODUKSI MERANTI, SUMATERA SELATAN)

Masyarakat lokal telah memanfaatkan lahan di kawasan hutan jauh sebelum diberikan izin usaha Hutan Tanaman Industri (HTI). Tumpang tindih pemanfaatan kedua pengguna berpotensi menimbulkan konflik. Tulisan ini mempelajari salah satu bentuk resolusi konflik dengan pengelolaan hutan secara kreatif dan kolaboratif. Resolusi konflik berdasarkan model Creativity and Collaboration Action–Forest Management (CCA-FM) dari temuan lapangan menciptakan pola partisipasi semua pihak dalam satu visi dengan prinsip ilmu kehutanan sebagai dasar penyusunan kebijakan. Metode pendekatan Convergent Parallel Mixed Method (CPMM) dilakukan dengan langkah kerja Rapid Land Tenure Assessment (RaTA). Hasil penelitian menunjukkan klaim masyarakat sebagai pemilik hak otoritas dan dominasi elit lokal, sangat mempengaruhi situasi aksi. Akan tetapi, pilihan kebijakan pemerintah terhadap luaran cenderung tidak mempertimbangkan kondisi lapangan. Model CCA-FM telah dipraktekan pada lima desa, berupa pemberian hak kelola kepada masyarakat dan fasilitasi transfer pengetahuan, teknologi, informasi pasar, dukungan berbagai pihak, dan kolaborasi dalam pengelolaan izin usaha. Hasil penelitian merekomendasikan agar CCA-FM dapat menjadi dasar pembangunan kemandirian desa dan meningkatkan kinerja Kesatuan Pengelolaan Hutan Produksi (KPHP).

Kata kunci: Kolaborasi, kreativitas, KPHP, pelembagaan desa, model CCA-FM

UDC/ODC 630*238(594.44)

Ahmad Junaedi

GROWTH PERFORMANCE OF THREE NATIVE TREE SPECIES FOR PULPWOOD PLANTATION IN DRAINED PEATLAND OF PELALAWAN DISTRICT, RIAU

(PERTUMBUHAN TIGA JENIS POHON LOKAL UNTUK DIKEMBANGKAN PADA HTI-PULP LAHAN GAMBUT YANG DIDRAINASE DI PELALAWAN, RIAU)

Produktivitas jenis pohon eksotik yang dikembangkan di HTI-pulp di Indoneisa terus menurun. Sementara itu, beberapa jenis pohon lokal mempunyai potensi untuk dikembangkan sebagai tanaman HTI-pulp. Akan tetapi, informasi mengenai performa jenis pohon

lokal tersebut belum tersedia dengan memadai jika secara khsusus akan dikembangkan di HTI-pulp. Penelitian ini dilakukan untuk mengevaluasi performa (kemampuan hidup, pertumbuhan dan hasil) tiga jenis pohon lokal lahan gambut [mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) dan geronggang (*Cratoxylum arborescens*)] yang berpotensi untuk dikembangkan di HTI-Pulp. Sebuah plot penelitian dibangun di lahan gambut yang dikeringkan di Pelalawan, Riau; dengan menanam ketiga pohon lokal tersebut dan ditambah jenis eksotik krasikarpa. Pengamatan dan analisis data dilakukan terhadap variabel kemampuan hidup, pertumbuhan, dan hasil dalam kaitannya untuk bahan baku pulp. Hasil penelitian menunjukkan bahwa geronggang (persen hidup 80%) dan mahang (persen hidup 65,6%) memiliki kemampuan hidup yang baik sampai pada umur 5,5 tahun dan secara nyata (p<0,05) lebih baik dibandingkan krasikarpa (persen hidup 22,4%). Pertumbuhan dan hasil kedua jenis ini pun sampai pada umur yang sama relatif baik, dengan riap tinggi 1,96 dan 2,31 m/tahun, diameter 2,08 dan 2,59 cm/tahun dan hasil 13,1 dan 21,4 m³/ha/tahun. Akan tetapi, pertumbuhan dan hasil tersebut secara signifikan (p<0,05) masih lebih rendah dibandingkan pada krasikarpa, diduga karena adanya perbedaan kualitas bibit. Hal ini mengindikasikan bahwa mahang dan geronggang merupakan kandidat kuat untuk dikembangkan pada HTI-pulp di lahan gambut. Namun, untuk sampai pada tahap pengembangan, program pemuliaan terhadap kedua jenis pohon lokal tersebut harus dilakukan.

Kata kunci: Jenis pohon lokal, bahan baku pulp, lahan gambut didrainase, kualitas bibit

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Saefudin, Efrida Basri and Agus Sukito

ANTIOXIDANT ACTIVITY AND TOXICITY EFFECT OF ELEVEN TYPES OF BARK EXTRACTS ACQUIRED FROM EUPHORBIACEAE

(*STUDI AKTIVITAS ANTIOKSIDAN DAN DAYA RACUN EKSTRAK KULIT 11 JENIS TANAMAN FAMILI EUPHORBIACEAE*)

Penggunaan bahan antioksidan alami untuk keperluan pengobatan perlu memperhatikan kemujaraban dan kemungkinan daya racunnya. Penelitian ini bertujuan mempelajari aktivitas antioksidan dan daya racun ekstrak kulit 11 jenis tanaman dari famili Euphorbiaceae. Awalnya, contoh kulit diekstraksi dengan etanol, dan hasilnya diperiksa bilangan peroksidanya dengan cara iodometri. Pemeriksaan fitokimia pada ekstrak kulit terhadap kemungkinan kandungan antioksidannya, yaitu polifenol, flavonoid, dan saponin; dilanjutkan dengan uji oksidasi-reduksi guna mencermati kemampuan ekstrak memangsa radikal bebas pada sumber baku (2,2-diphenyl-1-picrylhydrazyl/DPPH); guna menentukan ekstrak kulit mana yang paling berpotensi sebagai antioksidan. Eksrak kulit juga diuji toksisitasnya terhadap makluk hidup, khususnya manusia dicobakan pada jentik udang, menggunakan cara Brine Shrimp Lethality Test. Hasil penelitian menunjukkan ekstrak kulit dari empat jenis tanaman, yaitu *Acalypha hispida* Blume, *Bischofia javanica* Blume, *Glochidion arboreum* Blume, dan *Sapium baccatum* Roxb berpotensi sebagai antioksidan karena nilai peroksidanya (NP) lebih rendah atau sedikit di atas nilai peroksida kontrol positif vitamine E (NP 89,45 µg/ml). Akan tetapi ekstrak kulit dari *Euphorbia antiquorum* L., *Euphorbia hirta* L. dan *Jatropha podagrica* memiliki daya racun yang tinggi (masing-masing: 238,85; 228,11 dan 194,51 µg/ml) karena nilai LC50 < 1000 µg/ml.

Kata kunci : Bahan kulit, ekstrak etanol, bilangan peroksida, aktivitas antioksidan, toksisitas

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Krisdanto, Jasni and Tutiana

ANATOMICAL PROPERTIES OF NINE INDIGENOUS RATTAN SPECIES OF JAMBI, INDONESIA

(*SIFAT ANATOMI SEMBILAN JENIS ROTAN ASLI JAMBI, INDONESIA*)

Beberapa jenis rotan tumbuh secara alami di wilayah Jambi, Indonesia, yaitu opon *(Plectocomiopsis geminiflora (*Griff.*) Beccari)*, udang *(Korthalsia flagelaris* Miquel*)*, getah *(Daemonorops micracantha (*Griff.*) Beccari)*, duduk *(D. didymophylla* Beccari*)*, tunggal *(Calamus laevigatus* Martius*)*, sijau *(C. tumidus* Furtado*)*, buruk ati *(C. insignis* Griff. var. *longispinosus* Dransfield*)*, batu *(C. zonatus* Beccari*)*, dan paku *(C. exillis* Griff.*)*. Rotan tersebut termasuk rotan yang kurang dikenal, karena sifat dan karakteristiknya belum diketahui oleh konsumen dan penyuplai rotan. Tulisan ini mempelajari sifat anatomi sembilan jenis rotan yang tumbuh secara alami di Jambi. Observasi karakteristik anatomi batang rotan dilakukan dari contoh utuh, preparat sayatan, dan preparat maserasi. Hasil penelitian menunjukkan bahwa sifat dan karakteristik anatomi batang rotan dapat dijadikan karakteristik diagnostik untuk identifikasi jenis rotan. Berkas pembuluh pada bagian luar rotan opon dan udang memiliki lapisan berwarna kuning pada ujungnya (*yellow capped*). Perbandingan lebar dan tinggi berkas pembuluh bagian luar lebih dari satu, bentuk oval dijumpai pada rotan sijau, sementara bentuk lonjong memanjang dengan rasio lebar dan panjang kurang dari satu dijumpai pada rotan buruk ati. Berkas serat yang terpisah dari berkas pembuluh di bagian tengah dari parenkima dasar dijumpai pada rotan tunggal. Pada bagian luar batag, berkas serat membentuk satu atau dua garis dengan pola tidak beraturan terlihat pada rotan paku, sementara berkas serat dengan pola membentuk satu garis tampak pada rotan duduk. Saluran getah di bagian tengah dan luar bertipe tunggal dijumpai pada rotan batu, sedangkan pada rotan getah saluran getah berpasangan. Sifat anatomi batang rotan selanjutnya disusun dalam bentuk kunci determinasi untuk identifikasi jenis rotan. Untuk sembilan jenis rotan dari Jambi, kunci determinasi telah dikembangkan dan disarankan untuk dikembangkan untuk identifikasi genus untuk seluruh jenis rotan yang tumbuh di Indonesia.

Kata kunci: Sifat anatomi, sembilan jenis rotan asli, Jambi, kunci identifikasi

EARTHWORM POPULATION AT THE POST COAL MINING FIELD IN EAST KALIMANTAN, INDONESIA

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EARTHWORM POPULATION AT THE POST COAL MINING FIELD IN EAST KALIMANTAN, INDONESIA. Coal mining activities in Indonesia result in heavy soil degradation and significant decrease in earthworm population. This study aims to explore the population of earthworms at different ages of the plant in the post coal mining rehabilitation areas. PT. Kideco Jaya Agung, East Kalimantan. In this study, 5 samples (30 cm x 30 cm, 20 cm depth) of soil were collected from 5 rehabilitation sites. Sites were selected based on age after rehabilitation: 2, 4, 6, 8 and 10 years after replanting, and sampled with 20 m distances between samples to determine earthworm population. The depth of litter layer and species of plants were also recorded at each site. Chi square analysis was conducted to determine the significance of earthworm density in rehabilitation sites at different ages, while correlation analysis was conducted to determine correlation between litter thickness and the number of earthworms found in the research sites. Only 2 species of earthworms were found in this study; their abundance increased in line with the age of rehabilitation areas. The number of earthworms (density) at 10 years after rehabilitation was almost similar to that in the natural forests. In conclusion, planting tree species producing significant amount of litter might stimulate the earthworm community and initiate succession. It might also take more than 10 years to return to the previous state for the earthworms in terms of density after land rehabilitation of the coal mining areas is conducted.

Keywords: Coal mining, earthworm, litter, rehabilitation

POPULASI CACING PADA LAHAN BEKAS TAMBANG BATUBARA DI KALIMANTAN TIMUR, INDONESIA. Aktivitas pertambangan batubara di Indonesia telah menyebabkan kerusakan tanah yang parah dan menurunkan tingkat populasi cacing tanah. Penelitian ini bertujuan untuk mempelajari populasi cacing tanah di berbagai umur tanaman rehabilitasi pada lahan bekas tambang batubara, di PT Kideco Jaya Agung, Kalimantan Timur. Pada penelitian ini, untuk mengetahui populasi cacing dilakukan dengan mengambil sampel tanah pada lahan rehabilitasi dengan umur tanaman 2, 4, 6, 8, dan 10 tahun, sebanyak 5 sampel setiap tingkatan umur dengan ukuran 30cm x 30cm, kedalaman 20cm. Jarak antar sampel 20m. Ketebalan serasah juga diukur pada setiap sampel yang diambil. Analisis chi square dilakukan untuk mengetahui tingkat signifikansi kerapatan cacing pada setiap tingkatan umur rehabilitasi, sedangkan analisis korelasi dilakukan untuk mengetahui hubungan jumlah cacing dengan ketebalan serasah. Hasil penelitian menunjukkan bahwa hanya ditemukan 2 jenis cacing tanah dari semua lahan rehabilitasi, dimana jumlah populasi meningkat pada tiap tingkatan umur tanaman rehabilitasi. Namun demikian, populasi cacing pada lahan rehabilitasi dengan umur tanaman 10 tahun hampir sama dengan jumlah populasi cacing tanah pada hutan alam. Secara umum, penanaman pohon yang menghasilkan banyak serasah mampu menstimulasi peningkatan populasi cacing tanah dan menginisiasi suksesi. Selain itu, diperlukan waktu lebih dari 10 tahun bagi lahan bekas tambang batubara agar kerapatan cacing tanah kembali, seperti semula setelah dilakukan rehabilitasi.

Kata kunci: Tambang batubara, cacing tanah, serasah, rehabilitasi

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I. INTRODUCTION

The most common method in extracting coal in Indonesia is open pit mining. In this method, soil surfaces including its vegetation are removed before the coal is extracted (Endriantho, Ramli, Hasanuddin, & Hasanuddin, 2013). This method is often applied in this country because the abundant coal deposits are located closely to the earth surfaces. Although this method is considered to be the cheapest, open pit mining method results in several problems; heavy soil damage and soil compaction due to heavy vehicle activities (Haigh et al., 2015); soil erosion and sedimentation because of direct rainfall exposure to the open soil surfaces (Zhao et al., 2013); and an increase in toxic heavy metal in the soil, resulting in significant decrease of soil fauna population (de Quadros et al., 2016).

The open pit mining method in coal extraction also produce on acid mine drainage due to weathering processes in the dumping areas, leading to the oxidation of sulphide minerals, known as pyrite (FeS_2), which is in turn reducing soil fauna population (Simate & Ndlovu, 2014). Furthermore, a review conducted by Arnold and Williams (2016) reported that open pit mining could also create irreversible disturbances to biotic and abiotic ecosystem components including soil faunas. Thus, open pit mining method to extract coal results in negative consequences to the soil environment including earthworms and other soil faunas.

Earthworms could improve soil fertility and quality due to their role in litter decomposition and burrowing activities. In post mining areas, earthworms play important roles in improving and returning the soil quality in the rehabilitation areas. A study conducted by Pagenkemper et al. (2015) reported that earthworm activities improve soil properties such as bio-porosity, resulting in more favourable soil condition for the plants to grow. Moreover, Arnold and Williams (2016) reported that earthworms and other soil macro-faunas in the post mining rehabilitation areas are able to improve the macropore configuration, nutrient cycling and hydrological processes.

In addition, earthworm population could also be an indicator for restoration accomplishment in some restoration projects, as reported by Le Bayon, Bullinger-Weber, Gobat, and Guenat (2013), Barton and Moir (2015), Finngean, O'Grady, and Courtney (2018). It means that earthworm recolonization in the post mining rehabilitation areas is an essential feature in the post coal mining rehabilitation areas. Boyer and Wratten (2010) concluded that earthworms play important roles in accelerating restoration process and re-establishing the ecosystem functions in the post coal mining rehabilitation areas. Therefore, it is important to determine the earthworm population dynamics in the rehabilitation areas including in the post coal mining.

So far, research in earthworm population dynamic in the post coal mining areas have rarely been conducted in Indonesia. Mainly, studies related to coal mining impacts in Indonesia focus on rehabilitation methods and strategies (Ardika, 2013; Endriantho et al., 2013; Lizawati, Kartika, Alia, & Handayani, 2014); plant species selection for rehabilitation (Mawazin & Susilo, 2016; Susilo, 2016); vegetation structure and succession (Riswan, Harun, & Irsan, 2015; Soegiharto, Zuhud, Setiadi, & Masyud, 2017); and social aspects of coal mining activities (Apriyanto & Harini, 2013; Hidayat, Rustiadi, & Kartodihardjo, 2015). Meanwhile, Wibowo and Slamet (2017) conducted a study to determine soil macrofauna diversity in the post mining areas, however, the study was conducted in the post silica mining areas. In addition, Hilwan and Handayani (2013) studied the diversity of soil mesofauna and macrofauna in the post tin mining areas. Thus, studies focussing on earthworm population dynamic in the post coal mining areas are essential. This paper determines the population dynamics of earthworms at different ages of rehabilitation plants in the post coal mining rehabilitation areas in a coal mine in East Kalimantan, Indonesia. This study

was important to determine the duration of earthworm population to recover from heavily degraded soil and the factors influencing the recovery processes.

II. MATERIAL AND METHOD

A. Study Site

This study was conducted in a coal mine operated by the company PT. Kideco Jaya Agung, East Kalimantan, Indonesia, which was the third largest coal mining company in Indonesia (Figure 1.) The company has been established in 1982 and began to produce coal in 1993, while the rehabilitation of coal mining areas has been conducted since 1995 (Kideco, 2016). The research sites were located at five rehabilitation areas determined by the age of rehabilitation plants, which are managed by the company. However, although the company has conducted the rehabilitation activities since 1995, which meant that the company have some 17-years old rehabilitated areas, and it was hard to find some rehabilitated areas with plants more than 10 years of age because accurate locations were not provided.

Before the mining activities were conducted, the previous landscape in Kideco mining concession areas were dominated by primary and secondary tropical forests. This was the common features of pre-mining landscape in East Kalimantan, Indonesia. The company's total concession areas is about 23,000 ha located on dedicated forest areas granted from the Ministry of Forestry after applying concession scheme of forest areas. However, based on the regulations, the company could not occupied all of the concession areas and obliged to rehabilitate the damaged areas before returning the concession areas back to the government.

B. Methods

The earthworm collection was conducted in December 2012 by applying a purposive sampling method in the rehabilitation areas at different ages; 2, 4, 6, 8 and 10 years, which were determined by the time after rehabilitation. In this study, there were at least two main considerations in deciding and locating the samples: accessibility and safety. Some locations might no longer be accessible because there was no road maintenance. This was due to the coal extraction was finished. In addition, some locations were not save even if they were accessible because they were too close to the coal extraction activities using heavy vehicles.
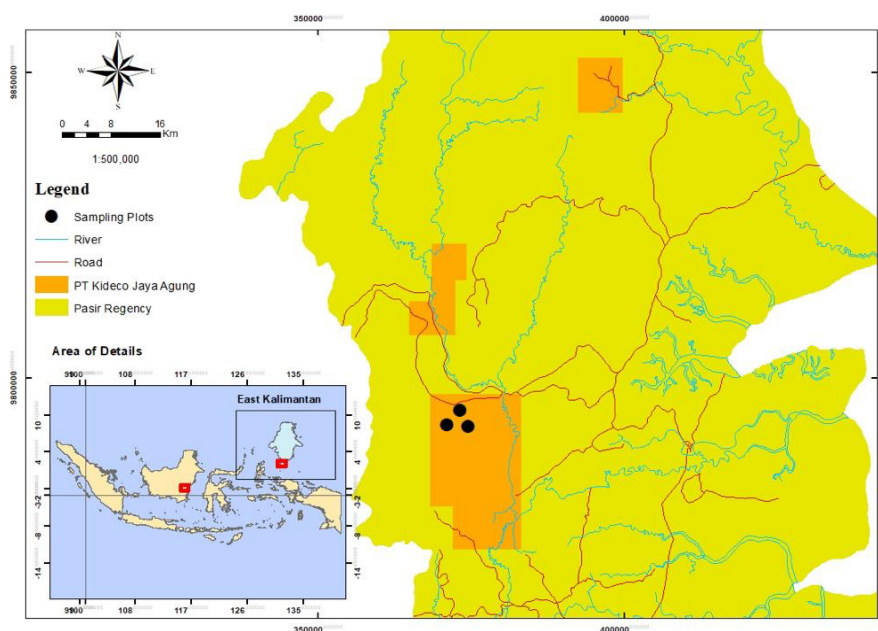
Figure 1. The Kideco company site location
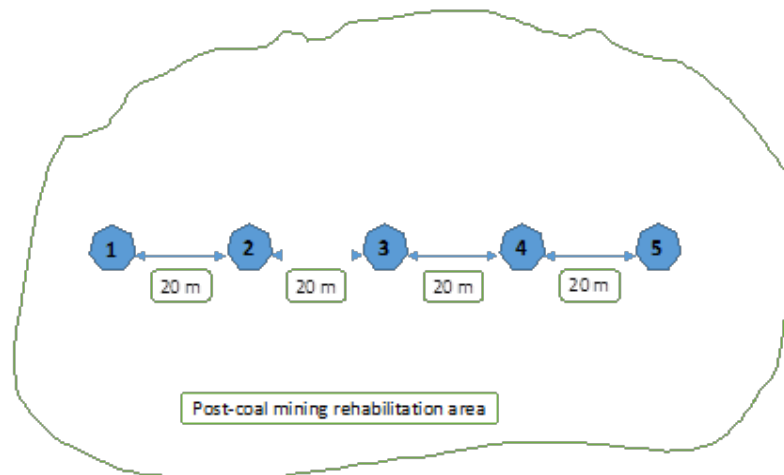
Figure 2. Illustration of sample placement at each of the rehabilitation area

The information about the age of the rehabilitation was obtained from the company's internal documents. To reduce the variability between rehabilitation sites, the study sites were placed as close as possible to each other using map provided by the company. For example, one year old rehabilitation areas should be as close as possible with 2 years old rehabilitation areas. This method was also applied in several earthworm and other soil biota studies (García-Pérez, Alarcón-Gutiérrez, Perroni, & Barois, 2014, Birkhofer et al. 2012).

In each of the five rehabilitation areas, transects were established and five soil samples were collected, with 20 m apart along the transect (Figure 2). Thus, in total of 25 samples were collected, each measuring 30 cm x 30 cm square, with 20 cm of depth (a soil block). The earthworms in each of the soil blocks were manually counted by hand-sorting in the field. In this method, each of the soil blocks was spread on a white paper and then, the earthworms were collected. Then, the earthworms were inserted in a bottle of formalin preservative liquid for later identification in the laboratory. Meanwhile, the litter depth was also measured at 3 points for each of the samples.

The hand-sorting method to count earthworms in this study had been applied in some soil macro fauna studies. This method has been acknowledged and standardized in Europe (Römbke, Sousa, Schouten, & Riepert, 2006) and it had several advantages in applying in the field; cheap and reliable (Schmidt, 2001; Smith, Potts, & Eggleton, 2008). However, the hand-sorting method had also some critics as it needs more human resources and less efficient (Jimenez, Lavelle, & Decaëns, 2006; Schmidt, 2001), therefore methods such as wet sieving to improve the accuracy was developed. Nevertheless, the extra methods to improve the accuracy were unable due to the limited transportation facilities. Especially, for the rehabilitation areas which have been abandoned for long period of time, there was no road maintenance, resulting in difficulties to access the areas.

C. Analysis

Taxonomic identification was conducted in the laboratory of *Balitek* KSDA (Research Institution of Natural Resources Conservation Technology) based on book entitled: *'Biologi Tanah: Ekologi dan Makrobiologi Tanah'* (Soil Biology: Ecology and Soil Macro-biology) written by Hanafiah, Anas, Napoleon, and Ghofar (2005). However, the taxonomic identification of the earthworms found in this research was only conducted up to the genus level determined from the morphological characteristics of the animals. Earthworm identification up to the species level was unable

to be conducted due to limited resources in the laboratory. As a consequence, the determination of the earthworm's characteristics (ecotype) in detail based on the type of food and how to find the food could not be conducted. Furthermore, although larger size of squaresamples (30 cm x 30 cm) was applied to prevent disturbances, instead of 25 x 25 cm as suggested by Smith et al. (2008), it was unable to measure the length and diameter of the earthworms; because the animals were in incomplete shape due to disturbances in the transporting process of the materials.

Chi square (X^2) statistics analysis was conducted to determine the significance of earthworm density in rehabilitation sites at different ages using a software "S plus 8". Based on a book entitled "*Statistika untuk Penelitian*" (Statistics for Research) written by Sugiyono (2005), chi square analysis is a non-parametric statistic to analyze data, which was obtained by counting, not measuring. Here, it was considered that the earthworms found in the point sample were counted. Moreover, at some point samples, earthworm was not found, which resulted in zero values. Therefore, non-parametric statistics were suitable for the statistic analysis in this study. Hypothesis used in this analysis were:

H_0: There was no significant difference in the earthworm density found at rehabilitation sites at the different ages

H_1: There were significant differences in the earthworm density found at rehabilitation sites at the different ages

In addition, statistics analysis using Microsoft Excel software was also conducted to determine correlation between litter thickness and the number of earthworms found in the research sites in chronological sequences.

III. RESULT AND DISCUSSION

A. Earthworm Abundance at the Different Ages of Rehabilitation Areas

Results showed that only two genus of earthworms were identified, which belong to two families in the coal mining rehabilitation areas in all ages of the rehabilitation areas (Table 1). The population of earthworms found in the ten years old rehabilitation areas was almost five times higher than the population of earthworms found in the two years old rehabilitation areas. There was a trend that the total number of earthworms found increased in accordance with the age of the rehabilitation areas. It was confirmed in the Chi square (X^2) analysis, which showed that there was a significant difference in earthworm density at rehabilitation sites from the age of 2, 4, 6, 8 and 10 years in this study. At 0.05 significance level ($\propto$ = 0.05), X^2 value was 74.4, compared to X^2 table 9.488. As a result, H_0 was rejected and H_1 was accepted. Therefore, it can be said that there was a significant increase in the earthworm density in the rehabilitation sites from the age of 2 years to 10 years.

In this study, *Pheretima* sp. was the dominant earthworm species found in this research because this species was found in the rehabilitation areas at all ages of the rehabilitation. *Pheretima* sp. was a species of earthworm, which could widely be found in several parts of Asia such as China (Fang, Liu, Zhou, Yuan, & Lam, 2014), Thailand (Iwai, 2017), Philippines (Aspe & James, 2018), Vietnam (Nguyen, Tran, & Nguyen, 2014) and

Table 1. The average population density of earthworms found in 2 to 10 years old rehabilitation areas in the post coal mining rehabilitation areas

Type of genus	Family	2 years	4 years	6 years	8 years	10 years
				Density (animal/m^{-2})		
Pheretima sp.	Megascolecidae	16	9	49	60	78
Lumbricus sp.	Lumbricidae		4	9		
	Total density	**16**	**13**	**58**	**60**	**78**
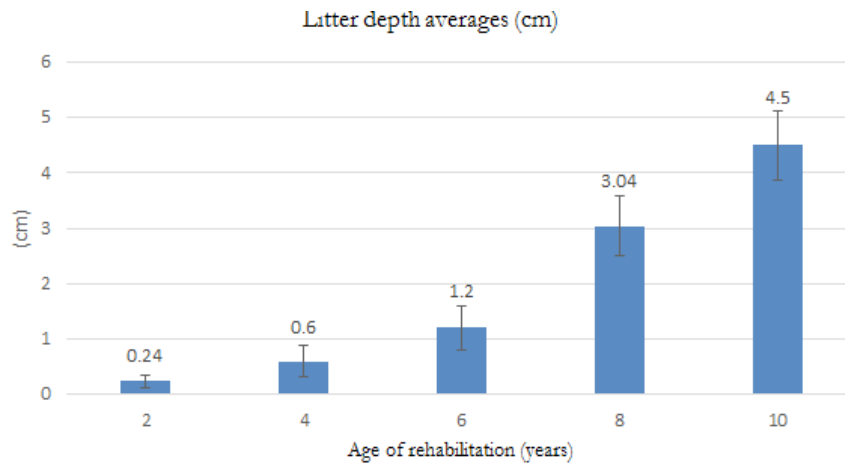
Figure 3. Litter layer depth at the different ages of the rehabilitation areas in the post coal mining rehabilitation areas

Table 2. Rehabilitation plant species planted in the concession areas of a coal mining company

Age of rehabilitation plants	Species
2	Sengon (*Falcataria moluccana*), sengon buto (*Enterelobium cyclocarpum*)
4	Sengon (*Falcataria moluccana*)
6	Sengon (*Falcataria moluccana*)
8	Akasia (*Acacia mangium*), sengon (*Falcataria moluccana*)
10	Sengon (*Falcataria moluccana*)

Malaysia (Teng et al., 2013). On the other hand, *Lumbricus* sp. could only be found in four and six years of age of the rehabilitation areas. This might be due to the characteristic differences between *Pheretima* sp. and *Lumbricus* sp. A study conducted by Anwar (2013) reported that *Pheretima* sp. was a geophagus earthworm species, characterized by soil as the main source of food and its capability in inhabiting low pH and low organic matter soil environment, which were the main feature of ultisol type of soil. Meanwhile, it was reported that *Lumbricus* sp. could be found in most parts of Europe (Milutinović, Tsekova, Milanović, & Stojanović, 2013). Hendrix et al. (2008) reported that *Lumbricus* sp. was native to Europe. However, this species was also introduced from Europe to several regions such as North America (Shartell, Lilleskov, & Storer, 2013; Stojanović, Tsekova, & Milutinović, 2014), Australia (Martinsson et al., 2015) and Asia (Hendrix et al., 2008).

Therefore, *Lumbricus* sp. could be categorized as non-native earthworm species in Indonesia.

Meanwhile, the litter depth of the rehabilitation plants at the age of two to ten years was presented in Figure 3. From the results, the litter depth increased in accordance with the age of the plants in the rehabilitation areas. The litter in the 10 years old rehabilitation sites was more than 20 times thicker than the litter in the two years old rehabilitation plant sites. This might be related to the type of species planted in the rehabilitation areas, which were fast growing plant species (Table 2). This type of plant species might be able to produce significant amount of litter in relatively short period of lifetime. A review conducted by Krisnawati, Kallio, and Kanninen (2011) by comparing the growth of *Acacia mangium* in several studies reported that, this species produced about 12–17 tonnes/ha of biomass at the age of one year, which then the production was significantly increasing to
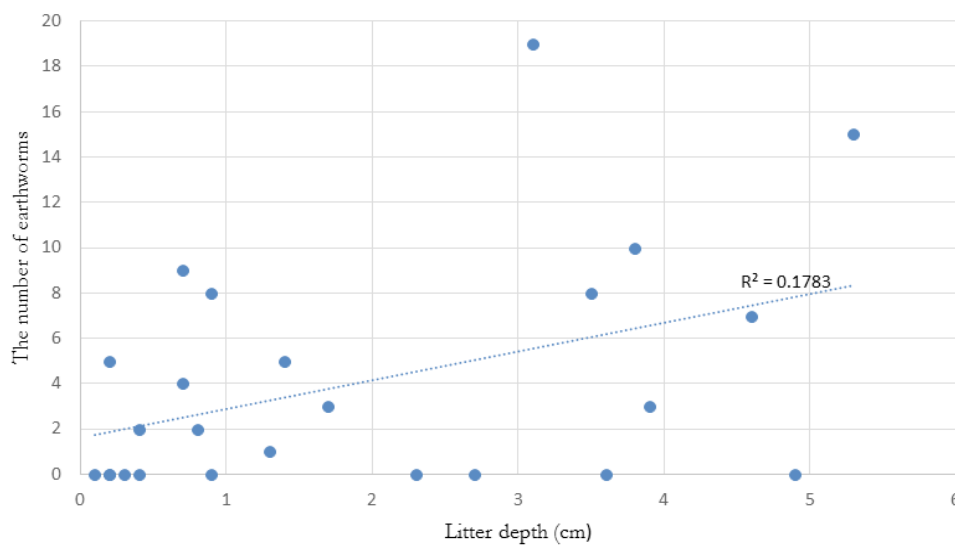
Figure 4. Relationships between litter depth and the number of earthworm found in the research sites

83—241 t/ha at the age of 10 years. In addition, Munawar and Suhartoyo (2013) reported that *Falcataria moluccana* produced 10.6 tonnes/ha litter. This indicated that fast growing plant species generated significant amount of litter, resulting in thick litter layer on the soil surfaces.

Figure 4 showed the relationship between earthworm population and litter depth in the post mining rehabilitation areas. The result of correlation analysis showed that correlation coefficient (R) between litter depth and the number of earthworms was 0.422, indicating that there was a positive linear correlation, in which the increase in litter depth was followed by the increase in the number of earthworms. On the other hand, the litter depth increased in accordance with the age of rehabilitation plants. Here, the production of litter increased as the rehabilitation plants grew. However, the correlation analysis showed that correlation determination (R^2) between the number of earthworms and litter thickness was only 0.17, indicating that there was a low correlation between the number of earthworms and litter thickness. It indicated that the increase in litter quantity were not the dominant factor causing the increase in earthworm population in the rehabilitation sites.

B. Factors Causing Increasing Earthworm Population in Rehabilitation Areas

In this study, litter quantity was an important factor that influenced the population of earthworms in the soil by providing favourable habitat for the earthworm as well as source of food. A study conducted by Abakumov, Cajthaml, Brus, and Frouz (2013) reported that rehabilitation plants accelerated C and N content in the soil, decreasing pH and increasing the amount of humic and fulvic acids, which in turn accelerating soil biotas colonization. Yatso and Lilleskov (2016) reported that leaf litter and soil type were essential factors influencing earthworm population growth. Meanwhile, Zhao et al. (2013) conducted a study by investigating the chronosequence impact of vegetation in the open cast coal mining areas from 1 to 13 years. The study revealed a significant increase in organic matter produced by the plants. The study also concluded that litter accumulation could initiate the succession in the post coal mining rehabilitation areas. Therefore, combined with the food availability, the litter thickness created favourable environment for the earthworm population to grow.

Food availability was a primary factor in influencing the earthworm population in the

post coal mining areas. This was also confirmed by Hlava, Hlavová, Hakl, and Fér (2015), who had conducted a study about succession in post opencast mining area. The study found that the population of earthworm in the forestry reclamation areas was higher compared to the population of earthworm in the agricultural reclamation areas, due to high food availability in the forest reclamation areas. The other research conducted by Emmerling (2014) reported that earthworm population in the 3 years un-cultivated area was higher than the earthworm population in the cultivated maize area due to the high availability of harvest residues as a source of food. Meanwhile, Kuntz et al. (2013) also reported that population of earthworm in reduced tillage farming system was higher than earthworm population in the conventional farming system because the food availability in the reduced tillage was more abundant.

On the other hand, the increasing population of earthworms in the study sites also had positive effects to the plants in the rehabilitation areas. The soil quality increased due to earthworm movement and activities in the soil, improving growth of the rehabilitation plants. A study conducted by Frouz, et al. (2013) concluded that earthworm bioturbation improved the soil development resulting in positive impact to the trees in the post mining afforested sites. In addition, a review conducted by Jouquet, Blanchart, and Capowiez (2014) reported that earthworms had several important roles in the post mining restoration; de-compacting soil, influencing water infiltration to control erosion, and improving soil organic matter. Therefore, there were mutual relationships between earthworms and trees in the rehabilitation areas.

The other factor causing an increase in earthworm population in this study was possibly earthworm invasion from the surrounding areas. This was possible because the concession areas of PT. Kideco mining company were surrounded by secondary and primary forests. Meanwhile, a study conducted by Russell, Farrish, Damoff, Coble, and Young (2016) reported that earthworm started to appear

at reclamation sites as early as 2-8 years after afforestation in Illinois, US, while Frouz, et al. (2013) showed that earthworms were found at reclamation sites after 2-5 years. However, the earthworm population in the native forests located near to the research sites were not determined due to inaccessible locations. Consequently, information about earthworm population in reference sites could not be presented. Although coal extraction using open cast mining method certainly created significant impacts on the soil micro and macro-faunas, detailed information about to what extent coal mining extraction makes some impacts to the earthworm population was not yet available.

C. Comparison of Earthworm Populations

Information about population and density of earthworms in the post coal mining rehabilitation areas in Indonesia was limited, therefore the population and density of earthworm in this study could only be compared with that population and density of earthworm in other habitats or land-uses. Several studies had shown that forest land use changes to other purposes such as agriculture and mining areas decreased the earthworm population in the soil (Agustina, 2016; Sri Dwiastuti, Sajidan, Suntoro, & Setyono, 2013). However, a study conducted by Hairiah et al. (2004) reported that forest land use change to coffee based agroforestry increased the earthworm population.

Compared to the other land uses, the density of earthworms in the 10 years old rehabilitation areas in the post coal mining areas in this study was slightly higher than that density of earthworms in the undisturbed forests, which was 78 animals/m² in this study compared to 75 animals/m² in the undisturbed forest (Table 3). Nevertheless, by considering to the other land use as a comparison, it could be said that after 10 years of rehabilitation activities, the density of earthworm population was almost similar to that earthworm density in the undisturbed forests. Therefore, it took more than 10 years in terms of earthworm density to return to the previous state after disturbances as a result of

Table 3. The number of species and density of earthworms in several land uses

Land use types	Density (animal m^{-2})	References
Undisturbed forests	75	F. X. Susilo, Murwani, Dewi, and Aini (2012), Hairiah et al. (2004)
Mixed coffee agroforestry	149	Hairiah et al. (2004)
F. moluccana plantation	16	S Dwiastuti and Suntoro (2011)
Peat < 50 cm thick with rubber plantation	183	Maftu'ah and Susanti (2009)
Post tin mining rehabilitation areas	82	Handayani (2009)

coal mining activities in the forest landscape in this study.

Several studies were conducted to determine earthworm population recovery in the mining rehabilitation areas in other regions. Indicated by the characteristics and amount of biomass, a study conducted by Dunger and Voigtländer (2009) reported that it took more than 50 years for the earthworm population to return to the pre-disturbance level after reclamation of post mining was conducted, finding 7 earthworm species. The other study reported that the rate of earthworm abundance increased by 3 individuals/year/m^2 and reaching 142 individu/m^2 after 21 years of restoration program which was started in Northern Illinois, US (Wodika, Klopf, & Baer, 2014). This number was similar to the native prairie located near to the study site.

D. Earthworm Re-colonization in The Post Coal Mining Areas: Is It Successful?

From the two genus of earthworms found in this study, Pheretima sp. could be considered to be a successful colonizer in the post mining environment particularly in East Kalimantan, Indonesia compared to Lumbricus sp. According to Eijsackers (2011), there were several characteristics for earthworms as a successful species colonizer; (1) the number of times a species could come first in the habitat, (2) habitat range in which a species was capable to establish, (3) endurance of a species living in a range of environmental conditions, and (4) species dominance in number or biomass at early successional stage. In this study, Pheretima

sp. had already been found in the 2nd year of rehabilitation areas, which was very early stage of colonization. This species also dominated at all stages of the rehabilitation time. Moreover, the fact that Pheretima sp. was found in the 2nd year of the rehabilitation time indicated that this species was able to live in hard conditions. The early stage of post rehabilitation was characterized by high temperature due to open areas and direct sunlight to the soil surfaces. At this stage, the soil surfaces were not covered by the plants' canopies.

However, recognizing the factors on how Pheretima sp. could survive and dominate the post mining habitat in this study were difficult because only a few factors could be observed. According to a review conducted by Eijsackers (2011) adapted from Bradshaw (1993), there were several factors influencing the success of earthworm as colonizers; (1) dispersal, (2) establishment and (3) population growth. In the post mining areas, the dispersal of Pheretima sp. might be occurred actively by top soil spreading before rehabilitation was conducted. Before coal extraction was conducted, the topsoil layer, which potentially contained earthworm was removed and retained for rehabilitation purposes. From the review, it was also discussed that the establishment of earthworms was influenced by biological characters such as reproduction, cocoon size and cocoon survival capacity, while earthworm population growth was influenced by maturation time combined with environmental factors such as moisture, pH and C/N ratio. However, because the species identification could only be conducted

up to genus level, factors influencing the establishment of *Pheretima* sp. in this study could not be discussed.

E. Management Implication

From this study, it could be seen that litter layer had played some important roles to the earthworm population; providing food and favourable environment. Therefore, it is important for the company to select species of trees that can produce more litter layer on the soil surface. Based on the legal regulation, coal mining companies are also suggested to plant fast growing species of plants when the rehabilitation is conducted. Then, it is enriched with local species of plants after 2 or 3 years of rehabilitation. Because they can grow fast, these fast growing species of plants are able to produce more litter on the soil surface. However, in East Kalimantan, fast growing species of plants are commonly exotic species. This type of species are threatening conservation efforts by altering forest structure in the future. Thus, it is important for the government to create some regulations mandating the coal mining companies using native plant species that produce more litter in the rehabilitation areas.

IV. CONCLUSION

In conclusion, there was a significant increase in earthworm population in accordance to the age of rehabilitation in the post coal mining areas in this study. There were only two genus of earthworm found in this study, indicating low species diversity in the research sites. Meanwhile, *Pheretima* sp. could be considered to be a successful colonizer in the post mining environment particularly in East Kalimantan, Indonesia compared to *Lumbricus* sp. Moreover, the increase in earthworm density has a positive correlation with the litter thickness on the soil surface. However, litter thickness was not the single factor causing increasing population of earthworms in this study. In the early stage of rehabilitation of coal mining areas, it is important to plant tree species which could produce significant amount of litter to

stimulate the earthworm population to increase and initiate succession. Subsequently, the rehabilitation plants will have some benefits from the increasing earthworm population in the soil. Finally, it took more than 10 years in terms of earthworm density to return to the previous state after disturbances as a result of coal mining activities in the forest landscape in this study.

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PHYSICAL AND MECHANICAL EVALUATION OF 8-YEARS-OLD ACACIA HYBRID (*Acacia mangium* x *A. auriculiformis*) CLONES FOR VARIOUS END USES

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PHYSICAL AND MECHANICAL EVALUATION OF 8-YEARS-OLD ACACIA HYBRID (*Acacia mangium* x *A. auriculiformis*) CLONES FOR VARIOUS END USES. Currently, clonal of forest tree is gaining importance due to the yield improvement and low variability in different wood characteristics. Hybrid trees from clonal forest are importantly characterized in term of wood quality for finding suitable uses. Accordingly, three clones (HD3, K47, H4) of 8-year-old Acacia hybrid (*Acacia mangium × A. auriculiformis*) were evaluated for inter-clonal comparison of its wood quality by evaluating their physical and mechanical properties as per Indian Standards. All tree clones were studied at breast high including diameter, heartwood content, and physical and mechanic properties. The Dbh of all three clones was around 30–35% and 60–70% greater than pure forms of *A. auriculiformis* and *A. mangium* of the same age, respectively. The volumetric shrinkage of all three clones was found to vary from 7.8 to 8.6%. The low shrinkage values may be attributed to higher dimensional stability of the wood of these clones. The data obtained in green and air-dry conditions were used to calculate 'suitability indices' with respect to teak (*Tectona grandis*) which was taken as a reference wood for comparison in India. All the suitability indices that these clones were either comparable or slightly lower than those of pure forms of *A. auriculiformis* and *A. mangium*. Less inter-clonal variation was observed in most of the suitability indices. Though, all the three clones were exclusively grown for their use in pulp and paper industry, but the comparative suitability figures for different end uses indicate that these clones could also be used for certain non-structural applications such as tool handles, light packing cases, pallets and light furniture.

Keywords: Acacia hybrid, clones, wood quality, mechanical properties, suitability figures

*EVALUASI SIFAT FISIK DAN MEKANIK KLON ACACIA HIBRID BERUMUR 8 TAHUN (*Acacia mangium × A. auriculiformis*) UNTUK BERBAGAI PENGGUNAAN AKHIR. Saat ini, pemanfaatan klon tanaman hutan merupakan hal penting karena variasi kualitas kayu yang bervariasi berdasarkan karakteristik kayu yang berbeda. Pohon hibrida dari hutan klon perlu dicirikan kualitas kayunya untuk menemukan yang terbaik dan sesuai penggunaannya. Untuk itu, tiga klon (HD3, K47, H4) dari akasia hibrida umur 8 tahun (*Acacia mangium × A. auriculiformis*) dievaluasi sebagai bentuk perbandingan antar klon terkait kualitas kayunya dengan mengevaluasi sifat fisik dan mekanik yang sesuai dengan Standar India. Contoh uji setinggi dada (dbh) dari ketiga klon dipelajari diameter batangnya, kandungan kayu teras, dan sifat fisik dan mekaniknya. Dbh dari ketiga klon itu sekitar 30-35% dan 60-70% lebih besar daripada bentuk murni *A. auriculiformis* dan *A. mangium* pada usia yang sama. Penyusutan volumetrik dari ketiga klon itu bervariasi dari 7,8 hingga 8,6%. Nilai penyusutan yang rendah dapat dikaitkan dengan stabilitas dimensi yang lebih tinggi dari klon kayu tersebut. Data yang diperoleh dalam kondisi segar dan kering udara digunakan untuk menghitung indeks kesesuaian mengacu pada kayu jati (*Tectona grandis*) yang diambil sebagai kayu referensi di India. Semua indeks kesesuaian dari klon ini dapat dibandingkan atau sedikit lebih rendah dari bentuk murni *A. auriculiformis* dan *A. mangium*. Tidak banyak variasi antar-klon yang diamati di sebagian besar indeks kesesuaian, walaupun ketiga klon tersebut secara eksklusif ditanam untuk industri pulp dan kertas, tetapi sifat-sifat kesesuaian secara komparatif untuk penggunaan akhir yang berbeda menunjukkan bahwa klon ini juga dapat digunakan untuk penggunaan non-struktural tertentu seperti gagang perkakas, kotak kemasan ringan, palet, dan perabotan ringan.*

Kata kunci: Akasia hibrida, klon, kualitas kayu, sifat mekanis, angka kesesuaian

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I. INTRODUCTION

The short rotation plantation wood is emerging as a major raw material resource due to the ban on felling of trees in the natural forests. In the past, plantations had mainly been raised through seedlings. *Acacia auriculiformis* was introduced in India in 1946 and now it has naturalized in this part of the sub-continent (Rai, 1995), whereas *A. mangium* was introduced during 1984-85 (Damodaran & Chacko, 1996). These species were found to be well adapted in its better form and growth rate and adaptability to wider geo-climatic conditions. As most of the plantations were raised through seeds, the variability was very high resulting in low yield over the years. In order to minimize the variability in wood characteristics and to increase the yield per unit area, the clonal forest tree has been given an importance role. Moreover, to obtain better stem form, longer clear bole height with lighter branching, plantations of acacia hybrids through clonal material have also been raised as these hybrid trees could possess some outstanding intermediate characteristics of their parents. In order to find the suitability these hybrids clones of lower age for different value added applications, its wood quality parameters should be evaluated.

There is less work has been done in India on the aspects of finding its better utilization. Rokeya et al. (2010) have studied various physical and mechanical properties of hybrid acacia (*Acacia auriculiformis × A. mangium*) and reported that the wood of Acacia hybrid is suitable for making furniture and other household articles. Ismail and Farawahida (2007) have studied the physical and mechanical properties of *Acacia mangium × Acacia auriculiformis* hybrid planted in Malaysia and found that improvements of acacia hybrid are only confined to growth characteristics and heart-rot resistance but not wood properties. Some of the anatomical features of *A. mangium × A. auriculiformis* hybrid grown in Indonesia with regard to pulp yield and paper strength have been studied by Yahya et al. (2010). The anatomical wood properties, chemical composition and wood density

acacia hybrid its parents, *A. mangium* and *A. auriculiformis*.

Acacia hybrids wood have been studied by various researchers. Tang et al. (2016) studied the potentials of these hybrids as an afforestation species for impoverished sand tailings in Malaysia. Kha (2000) reported that in Vietnam, the stem volume of acacia hybrids is 2-3 times greater than that of *A. mangium* and 3-4 times greater than that of *A. auriculiformis* of the same age. Similarly, plantations of some other hybrids of eucalyptus (*E. camaldulensis × E. grandis*) and poplar (*P. tomentosa × P. bolleana*) have also been raised and reported by various researchers. Loulidi et al. (2012) have studied various physical and mechanical properties of eucalyptus hybrid and compared the properties with its parental species. It was found that the wood of this hybrid has a rather important density classifying it among the mid-heavy wood, with strong nail withdrawal and it has interesting mechanical properties. Ma et al. (2015) have studied variation in the growth traits and wood properties of hybrid white poplar clones and recommended its utility as a raw material for pulp and paper making.

The Mysore Paper Mills (MPM) Ltd., Bhadravathi, a pulp and paper manufacturing industry in Shimoga District of India, has developed several clones of acacia and its hybrids and grown them under large-scale plantations on degraded forest land to meet its pulp wood requirement. These acacia hybrids originated from *A. mangium* as mother tree were designated as 'mangi-auriculis' (Amanulla et al., 2004). Various wood quality parameters of plantation grown *A. mangium* and *A. auriculiformis* have been studied and reported by many researchers (Kumar et al., 2006; Midon et al., 2002; Rao & Sujatha, 2004; Rao et al., 2007; Shanavas & Kumar, 2006; Sharma et al., 2011; Shukla et al., 2007a, 2007b). However, not much information is available on various wood properties and utilization potentials of clonal material for different end uses. This paper explores the possibility of using short rotation plantation trees obtained from clonal material,

for different applications. In view of the above, various physical and mechanical properties of clones of acacia hybrid were evaluated in green and air-dry conditions as per Indian Standards to find their suitability for various end uses. The inter comparison of different suitability indices of the clones was also studied and reported.

II. MATERIAL AND METHOD

A. Sampling

Five trees each of three clones (HD3, K47 and H4) of acacia hybrid (*A. mangium* × *A. auriculiformis*), developed by MPM were selected for the study. These clones were grown at three nearby locations (HD3 at Heddur, K47 at Kanive and H4 at Halawani in Karnataka state of India) having an annual rain fall of 2000-3000 mm. All the clones were grown in deep red, loam and lateritic soil, with well drainage. The trees were felled and logs were collected from the same plantation sites for all clones.

B. Evaluation of Properties

The diameter at breast height (dbh) and heartwood percentage were determined for all clones immediately after tree felling. Various physical and mechanical properties such as specific gravity, shrinkage, bending strength, compressive strength and hardness were evaluated for each tree of all three clones. Small clear specimens were prepared and tested in both green and air-dry conditions as per standard procedure (Shukla et al., 2007b).

1. Heartwood content

The heartwood was identified based on colour differentiation from the sapwood. To estimate heartwood percentage, the total diameter and heartwood diameter of the discs were measured in four directions. Total area of the disc and heartwood portion was calculated separately and heartwood percentage was calculated using the ratio of the area of the heartwood portion to the total area of the disc.

2. Specific gravity

Specific gravity was measured using test specimens of 2 cm × 2 cm × 5 cm in green and air-dry conditions. Green volume and oven-dry weight was used for computing the green specific gravity while air-dry value of volume and oven-dry weight was measured for air-dry specific gravity.

$$\text{Spesific Gravity} = \frac{w}{v} \text{ ....(1)}$$

where: w is oven-dry weight and v is green or air-dry volume of specimens.

3. Volumetric shrinkage

For the measurement of volumetric shrinkage, the specimen size was 2 cm × 2 cm × 6 cm. Specimens were weighed in green condition to 0.01 g accuracy and their volume was measured using the standard mercury displacement method. The specimens were initially air-dried and finally dried in the oven at 103±2°C for 48 hrs and the weight and volume were again measured to compute the volumetric shrinkage (V).

$$V(\%) = ((V_1 - V_0)/V_1)*100 \text{ ....(2)}$$

where: V_1 and V_0 are volumes in green and oven-dry conditions respectively.

4. Static bending

The size of specimen was 2 cm × 2 cm × 30 cm with a span length of 28 cm. The loading was applied at a constant rate of 1 mm/min on the tangential surface of the sample. Various strength parameters viz. modulus of rupture (*MOR*) and modulus of elasticity (*MOE*) were computed using equations as follows:

$$MOR = \frac{3p'l}{2bh^2} \text{ ....(3)}$$

$$MOE = \frac{pl^3}{4Dbh^3} \text{ ....(4)}$$

where: *p* is load (*kN*) at the limit of proportionality, *p*' is maximum load (*kN*), *l* is span (mm) of the test specimen, *b* is breadth (mm) of the test specimen, *h* is depth (mm) of the test specimen and *D* is deflection (mm) at the limit of proportionality.

5. Compression strength parallel to grain

The size of specimen was 2 cm × 2 cm × 8 cm in length, and the rate of loading was 0.6 mm/min. The compression strength parallel to the grain (maximum crushing stress, *MCS*) was calculated by equation 5 as follows:

$$MCS = \frac{P'}{A} \quad ....(5)$$

where: *p'* is maximum crushing load (kN) at break point and *A* an is area of cross section (mm²) of the specimen on which force was applied.

6. Compression strength perpendicular to grain

The size of specimen was 2 cm × 2 cm × 10 cm. Load was applied at the 2 cm × 2 cm cross-section on the tangential surface at a rate of 0.6 mm/min. The compressive strength perpendicular to the grain (compressive stress at elastic limit - *CS* at *EL*) was calculated by equation 6 as follows:

$$CS \text{ at EL} = \frac{P}{A} \quad ....(6)$$

where: *p* is load (kN) at the elastic limit and *A* is area of cross-section (mm²) of specimen on which force was applied.

7. Hardness under static indentation

The size of specimen was 5 cm × 5 cm × 5 cm. The load (kN) required to penetrate into the specimen with an hemispherical steel ball of 1.128 cm diameter to a depth of 0.564 cm was recorded. Measurements were made at the centre of the radial, tangential and end faces; no splitting or chipping occurred. The rate of loading was kept constant at 6 mm/min.

8. Suitability indices and figures

All the physical and mechanical properties evaluated in the green and air-dry conditions were used for computing the suitability indication (Rajput et al., 1996). The suitability figures of all the three clones were calculated using suitability indices for different industrial and engineering applications (Sekhar & Gulati, 1972).

9. Statistical analysis

The basic data on different physical and mechanical properties was subjected to basic statistical analysis for finding out the average values and standard deviations using SigmaStat software (Ver. 3.5). Analysis of variance was conducted out for finding the significant differences in various properties among the clones.

III. RESULT AND DISCUSSION

The average values of dbh, heartwood percentage, specific gravity and shrinkage of all the three acacia hybrid clones are shown in Table 1. Various mechanical properties of all the three clones in both green and air-dry conditions along with standard deviations are shown in Table 2. The comparative suitability indices of all the three clones along with the corresponding values of pure forms of *A. auriculiformis* and *A. mangium* (Kumar et al., 2006; Shukla et al., 2007b) are given in Table 3. The suitability figures of all the three clones for different industrial and engineering applications are listed in Table 4.

Table 2 indicates that air-dry values for most mechanical properties were substantially higher than corresponding green values. The analysis of variance shows that MOR in green condition, MOE in green and air-dry condition, MCS in green condition, CS at EL in air-dry condition and hardness in both conditions were significantly different among the clones. No significant difference was observed in average values of MOR and MCS in air-dry condition and CS at EL in green condition.

The green and air-dry values of different properties were used to calculate 'suitability indices', assigning a value of 100 toward teak as a reference (Rajput et al., 1996). The comparative suitability indices that all the three clones along with the corresponding values of pure forms of *A. auriculiformis* and *A. mangium* (Kumar et al., 2006; Shukla et al., 2007b) are given in Table 3. Due to lower shrinkage values in clones, the retention of shape for all three clones was higher than in pure forms.

Table 4 shows the suitability figures of all the three clones for different industrial and

Table 1. The average values of physical properties of three acacia hybrid clones

Clones	dbh (cm)	Heartwood (%)	Specific gravity		Volumetric shrinkage (%) (Green to oven-dry)
			Green (80±5%)	Air-dry (12±2%)	
HD3	48.96 (3.59)	57.9 (5.62)	0.445a (0.038)	0.486a (0.042)	8.6 (1.28)
K47	50.6 (2.62)	62.2 (5.42)	0.437a (0.039)	0.458ab (0.043)	8.1 (1.02)
H4	50.5 (5.01)	57.6 (2.76)	0.396b (0.029)	0.430bc (0.042)	7.8 (0.93)
P-value	ns	ns	< 0.001	< 0.001	ns

Remarks: Values in parenthesis are standard deviations; ns: non-significant; values within same column suffixed with different letters are significantly different at α=0.05

Table 2. The average values of mechanical properties of three acacia hybrid clones in green (80 ± 5%) and air-dry (12 ±2 %) conditions

Clones	MOR (MPa)		MOE (GPa)		MCS (MPa)		CS at EL (MPa)		Hardness (kN)	
	Green	Air-dry	Green	Air-dry	Green	Air-dry	Green	Air-dry	Green	Air-dry
HD3	58.4a (5.07)	78.0 (15.44)	8.6a (1.18)	10.7a (1.51)	26.2a (2.56)	43.4 (3.57)	3.7 (0.73)	6.1ab (1.12)	2.7a (0.30)	2.8a (0.54)
K47	54.0a (7.99)	76.6 (16.08)	7.7ab (1.66)	9.5ab (1.36)	25.9ab 2.93)	45.8 (4.21)	4.0 (0.90)	7.2a (1.22)	2.4b (0.41)	2.5b (0.42)
H4	46.9b (8.10)	73.6 (16.7)	6.6bc (1.48)	9.1bc (1.89)	22.6c 2.86)	41.7 (5.21)	3.1 (0.92)	5.5bc (1.01)	2.0c (0.27)	2.4bc (0.49)
P-value	< 0.001	ns	0.003	0.027	0.006	ns	ns	0.003	< 0.001	< 0.001

Remarks: Values in parenthesis are standard deviations; ns: non-significant; values within same column suffixed with different letters are significantly different at α=0.05

engineering applications. These figures were calculated by the method as described by Rajput et al. (1996) taking teak score 100 as standard in India for comparison of any timber for various applications. Clones HD3 and K47 are having similar suitability figures for different end uses whereas clone H4 showed lower values. Based on the suitability indices and composite suitability figures, the timber of clones HD3 and K47 could be used for tool handles, light packaging cases, pallets and light furniture. The clone H4 was found suitable for use as tool handles and light packaging cases.

It could be seen from Table 1 that after 8 years, the average dbh of the trees was 49 cm in HD3 and 51 cm in case of K47 and H4. The diameter of all these clones was around 30-35%

bigger than of pure forms of *A. auriculiformis* (Shukla et al., 2007b) and 60-70% bigger than pure forms of *A. mangium* (Kumar et al., 2006) of the same age. The sapwood was yellowish-white while heartwood was golden brown and was sharply distinct. The average heartwood was found to be 58% in HD3 and H4 and 62% in case of clone K47. As shown in Table 1, both dbh and heartwood percentages were not significantly different among the clones. The average specific gravity of HD3, K47 and H4 clones in green condition was found to be 0.445, 0.437 and 0.396, respectively, while air-dry specific gravity was 0.486, 0.458 and 0.430. The specific gravity was found to be significantly lower for all three clones compared to pure forms of *A. auriculiformis* and *A. mangium*

Table 3. Comparative suitability indices of clones and pure form of *A. auriculiformis* and *A. mangium*

Properties	Clones			*A. auriculiformis**	*A. mangium***
	HD3	K47	H4		
Weight at 12% MC	84	79	74	99	91
Strength as a beam	75	73	68	104	71
Stiffness as a beam	64	59	53	91	67
Suitability as a post	75	74	66	71	61
Shock resisting ability	67	64	57	89	74
Retention of shape	96	95	99	85	85
Hardness	56	56	45	72	68
Refractoriness	61	60	55	57	34

Souce: *Shukla et al. (2007b),   ** Kumar et al. (2006)

Table 4. Suitability figure for various end uses taking teak as 100

End use	Clones		
	HD3	K47	H4
Suitability for tool handles	129	123	112
Suitability for light packing cases	89	88	83
Suitability for pallets	82	79	71
Suitability for furniture	75	72	63
Suitability for construction	74	70	65
Suitability for oars and paddles	72	70	64

Source: Rajput et al. (1996)

(Kumar et al., 2006; Shukla et al., 2007b). No definite trend was observed for specific gravity of acacia hybrids as compared to their parents. Rokeya et al. (2010) have reported intermediate values of specific gravity whereas Suffian (2011) has observed lower values of acacia hybrids. The analysis of variance showed that the specific gravity in green condition is significantly different among the clones. However, the difference was not significant between clone HD3 and K47. Similarly, the average values of specific gravity in air-dry conditions were also significantly different among the clones. The volumetric shrinkage was found to be 8.6, 8.1 and 7.8% for HD3, K47 and H4 respectively and was not significantly different among the clones. Rokeya et al. (2010) have reported the values of volumetric shrinkage in the range of 9.7–13% for acacia hybrid of 9–12 years old. The low values of volumetric shrinkage found

in the present study indicate that the timber from all three clones is dimensionally stable and could be used for applications where this parameter is of prime importance.

IV. CONCLUSION

Various physical and mechanical properties of three 8-year-old acacia hybrid clones were studied and suitability indices were compared with pure forms of *A. auriculiformis* and *A. mangium* of identical age. Not much inter-clonal variation was observed in most of the properties. The dbh of all these clones was around 30–35% higher than that of pure form of *A. auriculiformis* and 60–70% bigger than pure form of *A. mangium*. However, the amount of heartwood was slightly lower compared to pure forms. The low values of volumetric shrinkage found in the present study indicate that the timber from all three clones is dimensionally

stable and can be used for applications where this parameter is of prime importance. All the suitability indices of these clones were either comparable or slightly lower than those of pure forms of *A. auriculiformis* and *A. mangium*. Although, all the clones were exclusively grown for their use in pulp and paper industry, but comparative suitability indices show that these clones can also be used for application such as tool handles, light packaging cases, pallets and light furniture.

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CONFLICT RESOLUTION CONCEPT: IMPLEMENTATION OF CCA-FM MODEL IN MERANTI FOREST MANAGEMENT UNIT, SOUTH SUMATRA

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CONFLICT RESOLUTION CONCEPT: IMPLEMENTATION OF CCA-FM MODEL IN MERANTI FOREST MANAGEMENT UNIT, SOUTH SUMATERA. Local communities have been using forest land area far before Industrial Forest Plantation (HTI) permit was granted. The overlapping land use among different users potentially leads to conflict. This paper studies conflict resolution creatively and collaboratively with forest management. Conflict resolution is based on the Creativity and Collaboration Action - Forest Management (CCA-FM) model on field exploration that created participation pattern of all parties in the vision of forestry science principles as the basis of policymaking. Convergent Parallel Mixed Method (CPMM) approaches with Rapid Land Tenure Assessment (RaTA) were used. Results show that claim of the community as the owner of the authority rights and dominance of the local elites, greatly affect the action situation. However, the policy options taken by the government towards policy outcomes do not tend to consider the field conditions. The CCA-FM model has been implemented in five villages. The community strongly supports the government to devolve the management rights to the community and to facilitate the transfer of knowledge, technology, market information, supporting all parties, and collaboration on business license management. Research results recommend the CCA-FM model could be a basis for building village self-reliance and improving the performance of the Forest Management Unit (FMU).

Keywords: Collaboration, creativity, FMU, institutionalization of villages, CCA-FM model

KONSEP RESOLUSI KONFLIK: IMPLEMENTASI MODEL CCA-FM DI KESATUAN PENGELOLAAN HUTAN PRODUKSI MERANTI, SUMATERA SELATAN. Masyarakat lokal telah memanfaatkan lahan di kawasan hutan jauh sebelum diberikan izin usaha Hutan Tanaman Industri (HTI). Tumpang tindih pemanfaatan kedua pengguna berpotensi menimbulkan konflik. Tulisan ini mempelajari salah satu bentuk resolusi konflik dengan pengelolaan hutan secara kreatif dan kolaboratif. Resolusi konflik berdasarkan model Creativity and Collaboration Action – Forest Management (CCA-FM) dari temuan lapangan menciptakan pola partisipasi semua pihak dalam satu visi dengan prinsip ilmu kehutanan sebagai dasar penyusunan kebijakan. Metode pendekatan Convergent Parallel Mixed Method (CPMM) dilakukan dengan langkah kerja Rapid Land Tenure Assessment (RaTA). Hasil penelitian menunjukkan klaim masyarakat sebagai pemilik hak otoritas dan dominasi elit lokal, sangat mempengaruhi situasi aksi. Akan tetapi, pilihan kebijakan pemerintah terhadap luaran cenderung tidak mempertimbangkan kondisi lapangan. Model CCA-FM telah dipraktekan pada lima desa, berupa pemberian hak kelola kepada masyarakat dan fasilitasi transfer pengetahuan, teknologi, informasi pasar, dukungan berbagai pihak, dan kolaborasi dalam pengelolaan izin usaha. Hasil penelitian merekomendasikan agar CCA-FM dapat menjadi dasar pembangunan kemandirian desa dan meningkatkan kinerja Kesatuan Pengelolaan Hutan Produksi (KPHP).

Kata kunci: Kolaborasi, kreativitas, KPHP, pelembagaan desa, model CCA-FM

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I. INTRODUCTION

Forest management by rural communities around forests is not merely an economic and ecological but also sociological and anthropological issue (Charnley & Poe, 2007). The community's role in forest management is also closely related to variety of issues; diversity of knowledge based on their local wisdom (Bushley & Khanal 2012); ease of operational management (Nayak & Berkes, 2008); human environment and livelihood (Nayak & Berkes, 2008; Ming'ate et al., 2014); protection of local resources (Pandit & Bevilacqua, 2011; Bijaya et al., 2016); and easing of government tasks (Suharjito, 2009). In the field, the fact shows that people living around the forest are also involved in illegal logging, shifting cultivation and forest occupation. Community of the surrounding forest doesn't always has conservation efforts, (Rasolofoson, Ferraro, Jenkins, & Jones, 2015) and does not necessarily make sustainable use of it the forest (Meilby et al., 2014). Debate shows different perspectives of forest villages and scientific discourse.

Although, over the last twenty years, the government has made changes to previous official forest management processes by transferring the rights to the community governance, including indigenous peoples and forest farmers through Community Forest (CF) or Villages Forest (VF) program (PSKL, 2015; KLHK, 2015a), however in reality, there is still disbelief in implementing the program. Forest area conversion data related to oil palm and rubber plantations, productive agricultural lands and settlements (FAO, 2015; Tsujino, Yumoto, Kitamura, Djamaluddin, & Darnaedi, 2016) became the basic reason for government to prevent community's claim and enclave to the forest areas. However, it is undeniable that degradation and deforestation in Indonesia occurred, due to the bad forest management system condition during Rights of Forest Concession (RoFC) era (Kartodihardjo, 1998; Holmes, 2002; Colfer & Capistrano, 2006). Reluctance could be seen by overlapping rules and policies in the determination of the

right from the law in the minister's decision level (Hermosilla & Fay, 2006). The process of formal legal change is complicating the role of communities in forest management (Kartodiharjo, 2013).

Local community or household leaders who use the land in the forest area are seen by the government as an individu who has illegal accessto forest and forest destruction. Based on that assumption, the government launched the new permit to arise new issues of the conflict due to overlapping use and utilization between users (Wicke et al.,2011; Anderson et al., 2013; Gamin et al., 2014). Thus, owners have legal permits but lack the legitimacy to the local communities. Sustainable forest management targets in the 2010-2014 The Ministry of Environment and Forestry Strategic Plans are not easily achieved due to various factor (Kemenhut, 2014; KLHK, 2015b). The factors include unfairness of land allocation which causes social conflicts across Indonesia and sharpens the uncertainty of property rights; deteriorating forest conditions due to illegal logging, fires and utility rivalries (Hardin, 1968; Dolšak & Ostrom, 2003). There are differences in views between users because it is not possible to understand the wishes of each party. For example, legal permit has not been issued to people who use forest areas and take forest products as livelihoods. The way communities meet their needs is even more likely to be considered as an illegal activity. However, on the other hand, there is unfriendly forest exploitation and non-procedural permits of oil palm and rubber plantations, which are apparently allowed.

The role of rural communities with social and cultural capital actually could be generated within site-level management units. The activities of institutionalization of village communities, i.e.: determining the form of management, providing the rules of use, and determining the user. Ongoing utilization conflict resulting in optimal management objectives which is a form of policy failure (Kartodihardjo, 2013). Exogenous institutional factors, particulaly attributes of communities, are expected to

affect deteriorating conditions and biophysical attributes. Rules in use and conditions of biophysical characteristics resulting in competition between management patterns and community land claims (Dolšak & Ostrom, 2003). Conflict due to the competition between users (Sheil & Wunder, 2002; Ribot et al., 2006) and the lack of well-built social interaction cause inoptimal institutional performance (Ostrom & Basurto, 2011). The absence of a community's role in attribute community actually can turn the outcome into conflict input or attribute community that could change the outcome (Charnley & Poe, 2007; Gibson, McKean, & Ostrom, 2000). Institutionalization of rural communities which has social capital could drive socio-economic and socio-ecological aspects on forest management (Pretty & Ward, 2001; Gilmour, 2016). The study of communities' roles in forest management is not something new. Researchers' attention has highlighted the role of communities in forest management. This paper studies the institutional form of the community in regulating the use of forest areas, and in designing the role of local residents to legitimize the government's concession permit.

II. MATERIAL AND METHOD

The research is located in Musi Banyuasin Regency, South Sumatera Province from September 2015 to September 2016. This research used the Convergent Parallel Mixed Method (CPMM) approach (Creswell, 2013) for the complete research. For this part it use the qualitative method by constructivism approach. Data collection included information about land use and land use change (LULUC), literature studies, and history of the villages. Data were collected from respondent with open interviews to obtain the communities' perspective. The next steps were Focus Group Discussions (FGDs) to summarize the open interviews and discused it with stakeholders. The total number of key informants was 123, consisting of 97 informants from community members in eight villages, 4 persons from the Ministry of Forestry, 8 persons from the District Forestry Service, 4 persons from the Provincial Forestry Service, 5 persons from the technical implementation office (UPT) and 5 persons from the Industrial Forest Plantation as forestry business license holders. Data were collected by step work of RaTA (*Rapid Land Tenure Assessment*) (Galudra et al., 2010) see Figure 1.
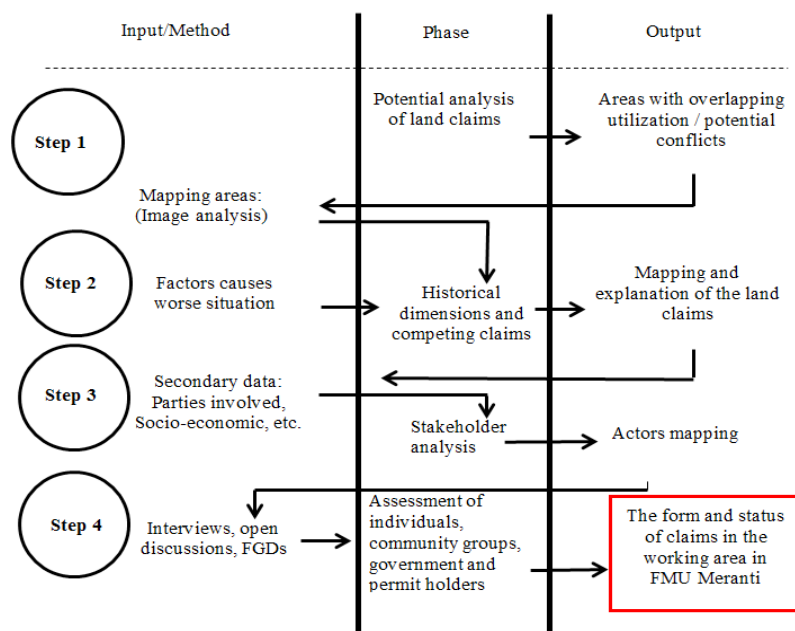
Figure 1. Four stages and RaTA targets

Source: Modification of RaTA (Galudra et al., 2010)

III. RESULT AND DISCUSSION

A. Collaboration of Community Roles

1. Encouraging villagers as agents of change

In this study, the operational definition of the community's authority is a social power in a general relationship to determine the legitimacy of others (Nurrochmat et al., 2016). The authority of the village community is their authority in building the legitimacy of other users outside the village. The community's authority was built from collective action for collaboration and creative activities for taking care of the forest and improving the community economically. The operational definition of the collective action is a will and one vision among all parties through collaborative and creative action on forest management. The collective action among all parties (local community, permit owners, FMU Meranti, and other stakeholders) is to be in a new form of forest management (see Maryudi et al., 2018). The mobilization of ethnic identity in the local political economy is shown in Figure 2.

The interest domination of the local elite will control the decision, although these issues are still debated. (Mills, 1956), explained that the elite can gain its power from inheritance,

and from the control of the highest position in the hierarchy of politics, business, and shared values and beliefs. Moreover, it is also caused by the nature of people does not want to be opponent in the group. Sjaf et al. (2012) explained that the results of the actor's practice will reflect in his identity as modus operandi. It is influenced by experience in interpreting the reality that happened. The modus operandi becomes an identity which isolates the actor. The actor at this village-level is associated with the dominant symbolic power as happened in the Musi Banyuasin community as part of a clan group. Symbolic powers appear in the family of former "pesirah" or religious leaders (doxa of symbolic power). The establishment of the elite identity either individually or collectively is in a space called the structure of ethnic identity formation (Nayak & Berkes, 2008). The existence of the dominant position of the local elite from its ethnic identity needs to be changed in the forest utilization arrangements by mobilizing ethnic multiculturalism. Local elites in the indigenous Kubu and Banyuasin tribes are very dominant. It needs to mobilize the spontaneous migrants to change the autonomous rights of the symbolic power of the elite to become heteronomous and have the
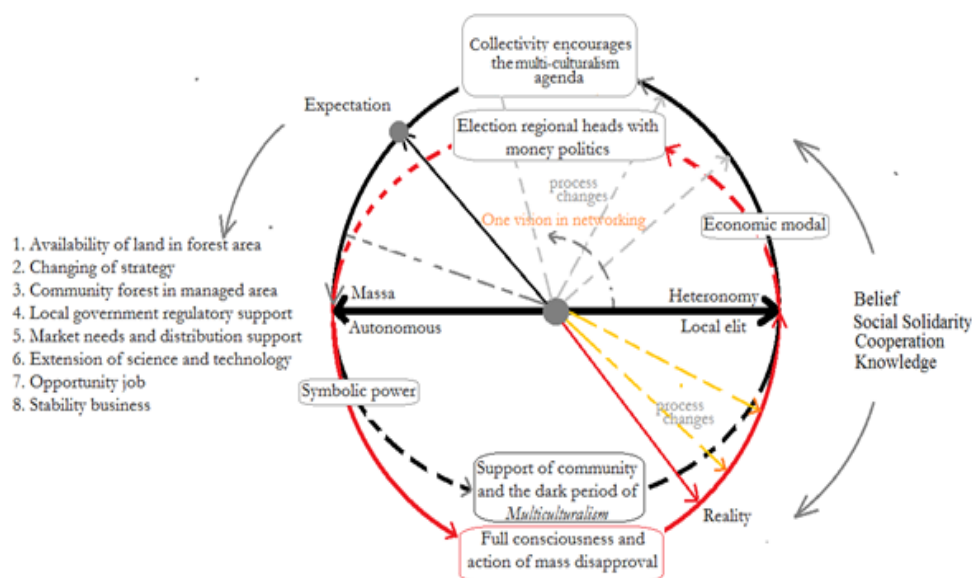
Figure 2. Mobilizing ethnic identity in the local political economy arena

Source: Sjaf et al. (2012)

communities multiculturalism/mass. This step is the last choice, if the negative impacts from the local elite continuously happening, it will lead to forest damage (land transaction, illegal logging).

The position of local elites in field conditions which strengthen the autonomous position with symbolic capital becomes a separate constraint in forest management. The act of buying and selling land which is done by the local elite is expected to be changed by the collective action of multiculturalism. All parties protect the forest with a collective consciousness (Sjaf et al., 2012). The community's participation is necessary to strengthen the concept of collective action at operational level of forest management (Mazur & Stakhanov, 2008; Ningsih, 2008) which can ease government tasks (Suharjito, 2009).

2. One vision in networking

The community's claim to the land which has become rubber plantation usually called "pararimbo", it became a capital demand for the enclave land from the forest area. In logical dialectics when elite networking is formed in interaction with society or groups it is a shadow and it usually has the personal interest. For example, when a company has to apply for the boundary of a work area, the local elites mobilize communities to impede the implementation of the boundaries, and commence work on the sites. It could happen because the village community has one vision in networking.

Perceptions of community groups was influenced by different factors, i.e.: the inability of economic capital, the will to preserve culture that is seen from their daily activities in forest areas including livelihoods, and the influence and ability of local elites who wants to gain benefit of land utilization versus charism of symbolic power from the customary leader who wants to keep his uniqueness in local traditions (Sukwika et al., 2016). These three factors have caused land controlling motives as follows: direct personal gain, assisting the company with the purpose of personal gain and the solidarity motive of the ethnic groups in order for indigenous peoples to retain the land. The
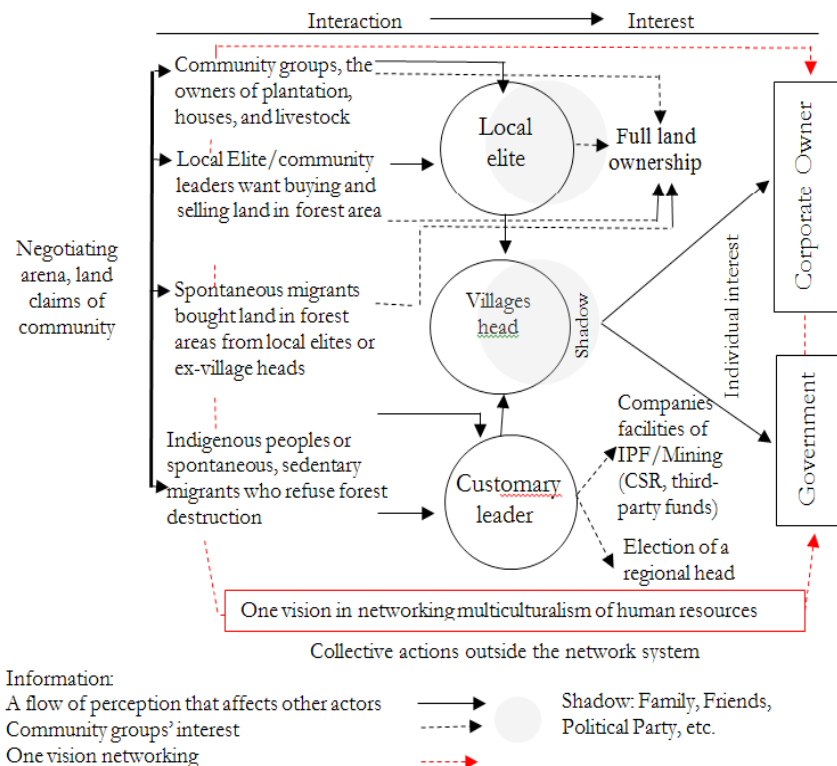
Figure 3. Flow of interaction with interest parties

flow of interest between all parties is shown in Figure 3.

The three interests influence each other on the role of the village head as the government representative in land claims. Based on the pattern of interactions, perception of community groups are expressed to the Village Head and the company, and also hidden interests: to get CSR funds, to get full ownership of land and to cut logs by logger known as "*anak kapak*". The symbolic power of customary leaders is used to refuse company by jargon their heritage land and also to support village head elections. Another story is that community group convey their interest to the local elite or customary leader and it will be continued to the village head. Then, the village head will deliver their aspiration to the government and company. The village head often has a hidden personal interest from a shadowing interest such as families or colleagues.

3. The human resources from multiculturalism

The lack of capacity of the human resources has always been the discourse of forest management for participating rural communities. The human resource also underlies the government's argument in building its exclusiveness on forest areas, despite that the real welfare of the community is part of the government's development goals. Forest management to support development is understood differently from the concept of development at operational level. In many other cases, however, communities have improved their economies by agroforestry systems in forest areas such as in West Sumatera through the concept of community forest (Hamzah, 2015). Many research explained that the agroforestry system has financial benefits and vocation for the community (Kusumanto, & Sirait, 2001). It was supported by research developed by researchers from the Bogor Agricultural University in Krui-Lampung. It was explained that the "damar" agroforestry could increase the community's income and absorb labour better than oil palm and rubber

plantation (IPB (2002) in Contreras-Hermosilla and Fay (2006)). Based on this result, the role of community in forest management is not a crtitical problem. Discourse about the uncertainty of land ownership and the role of the community is not a critical promblem either (Yasmi et al., 2012; Silalahi & Erwin, 2013).

B. Institutionalization of Villages

Institutionalization of village communities in regulating and determining forest area management was recognized by various academics and experts. It is believed that there is a potential development in managing forests based on existing cultural structures for effective and participatory resource management. The same thing was built by the people of Baduy, Ammatoa and Rumahkayu (Iskandar et al., 2017; Ichwandi & Shinohara, 2007; Husain, & Kanasih, 2010; Ohorella et al., 2011). Institutionalization of the village community in the FMU Meranti area is coming from various community origins, so collectivism is necessary to ecourage the multicultural agenda. There is an area that claimed, it has been managed by the community was given the management right with its village institutionalization. Therefore, FMU is expected to be driving and facilitating the technology and knowledge to encourage the economic increase of community and forest sustainability.

Institutionalization of the village and the community development is required, as stipulated in Law No. 26/2014, as a basis for the development of local institution independently. In fact, the concept to reposition unit level manager by establishing FMU Meranti as the real management rights is not optimal in the field. Village institutionalization by establishing Village Owned Enterprises (BUM-Desa) for forest management as village fund, and then village fund allocations are applied to manage the forest area in FMU Meranti optimally. Village institutionalization was done through collective action by creativity and collaboration to support the government.

C. Strategy of Village Institutionalization

The strategy of forest management could be implemented with village institutionalization through collective action in creativities and collaborative actions. Understanding the strategy of village institutionalization is repositioning the local elite and community leader in collective action on forest management through Model Creativity and Collaborative Action Forest Management (MCCA-FM) based on field exploration.

The solution of utilization conflict in FMU Meranti could be overcome by the role of the community or institutionalization of the community in forest area arrangement. The village government as the smallest form of government should be able to regulate itself. Local elites who feel the authority to regulate forests are organized to participate in collective action. Local communities from various stakeholders have to work together in a local management institution which is called village institution to develop the BUM-Desa. FMU Meranti who has the management rights should be willing to hand over the management rights to public authorities. FMU Meranti could support and disseminate farm knowledge, technology sharing, inviting the investors and promoting community products on the open market as described in Figure 4.

D. Villagers Become Forest Managers

Forest areas claimed by communities and community managers are the focus of development. Community's land claims are defined as "village assets". Forest management is an individually managed forest area but is used as village asset. Smallholder plantations in forest areas are granted management rights to the community as plantation land. The management rights of the community are determined by the government or the Ministry of Forestry (MoF) in the forest area. Therefore, the rules in use for production forest areas, which prioritize the interests of large capital owners, need to be changed. Furthermore, the government through FMU Meranti management level unit should support the science, technology and also provide facilities. The strategy of policy change remains based on the functions and forestry science as policy analysis. Rural communities' role can be seen from field problems and activity objectives. Creativity and collaboration scenarios (MCCA-FM) are started ranging from reality, problems, expectations, strategy, and output.
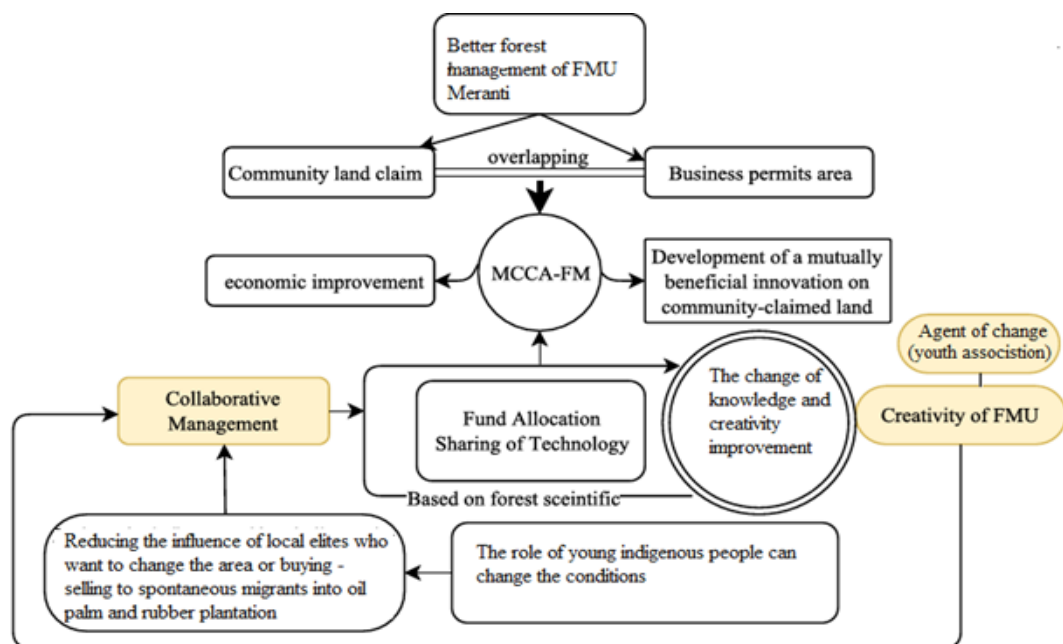
Figure 4. Strategy of village institutionalization

The actual conditions and problems that occurred at FMU Meranti became the basis for model development. The fact that the community has managed the forest area cannot be denied and it is a risk element. The field condition is a real condition which does not match the expectation and became the problem. This condition has to change in accordance with expectation and its output. Therefore, the changing can be done through creativeness and collaboration. Creativity is the addition of the idea, whereas the collaboration is the collective action for better forest management. Collaboration can be implemented through socialization, dissemination, and changing of regulation and law.

The realities of field conditions: forest area which is state property was claimed by community; oil palm and rubber as main local commodities; the prevailing regulations with prohibition of oil palm plantations; production forest areas have IFP and mining business licenses; low benefits of forests to support the community's economy; and lack of information and technology to improve capacity of human resources. Expectations in forest management include: Stability and legitimacy of IFP and other permits, State/non-tax revenues from production forest areas are increased, and communities land claim can be managed intensively. Implementation of MCCA-FM will provide the output of FMU expectation as follows: availability of community land in the forest area; changing the strategy of FMU Meranti into optimal performance; granting forest management license to community; local government support and regulations; availability of market product and distribution process; extension of science and technology and availability of vocation. The element of reality, problem, strategy and process of MCCA-FM, is shown in Figure 5.

E. Village Roles in CCA-FM Model

1. User determination

In determining forest area users, the community is considering various factors, among others: capital capability; management capability; public convenience and understanding the community's condition. The community's expectations to the new users are those that can support and improve the
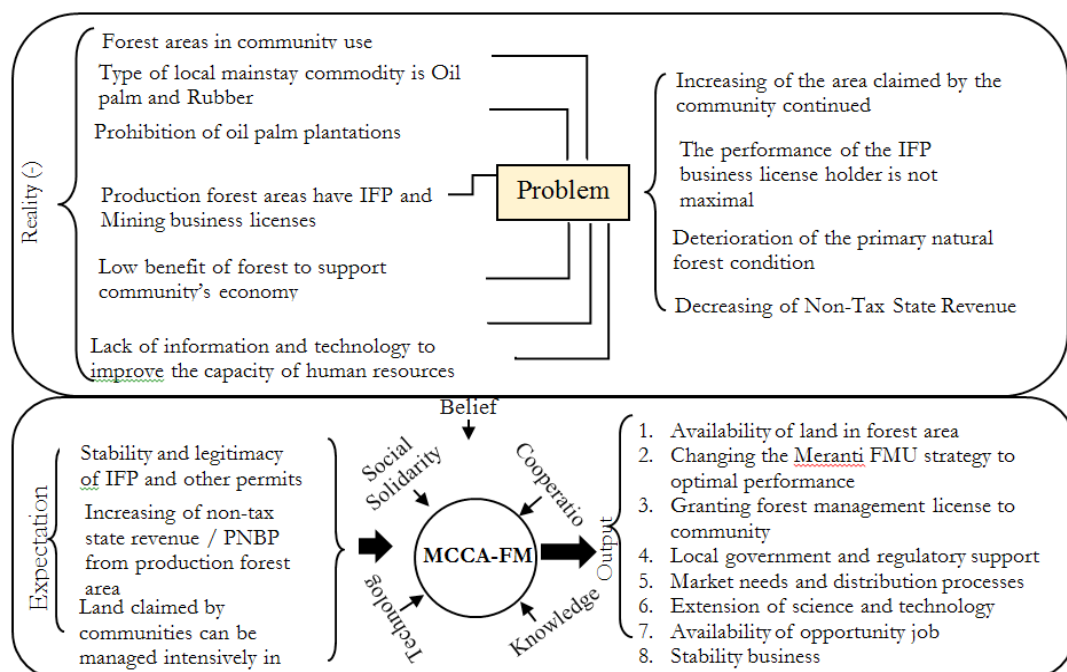
Figure 5. Element of reality, problem, strategy and process MCCA-FM

economy of the community (Nurrochmat et al., 2017). To achieve that, the community needs to select the users. It is possible for the FMU in supporting activities to provide investors with what the community is expecting and provide business stability. It becomes a challenge for FMU.

Government and all related parties support investors who can collaborate with the community and will deliver healthy business conditions and forest health. User choice will be influenced by biophysical characteristics, community characteristics, laws and regulations, financial ability, social and economic conditions, and technology (Došlak & Ostrom, 2003). Linking the two choices between the community and the capital owner or investor, role of the government in support of technology, knowledge, and rules are indispensable.

2. *Determination of forest commodity production*

Determination of production type is decided by the village meeting and the capital owner. The determination of the kind of forest product production was set to consumer's choice theory (Smith 1759) that the type of business is strongly influenced by market sentiment. Market sentiment is influenced by the availability of goods and services. The choice of the kind of forest commodity production is a concept of one village one product. The two main factors in determining the kind of production are having commercial value and product that is appropriate to the growing site.

The arrangement for the forest commodity production is needed to avoid the practice of clearing forest land due to the fact that the company already has the same kind of commodity with the community. Consumer's choice tends to choose the same products as other users due to the ease of access to the market, and the availability of infrastructure facilities. The concept of the similarity on product types in forest management is avoided as far as possible to prevent new land clearing in the forest area. It could be seen on the development of palm oil and rubber

plantations in FMU of Meranti area, which is land clearing of the forest area converted by the community, generally into palm and rubber plantation due to there is market for both kinds of these commodities. In addition, the limited land will lead to new land clearing in forest areas and threaten it. The factors to determine the forest commodity production follows the availability of good quality seeds, having commercial value, and natural growing site besides avoiding similarity of products. The role of community in managing commodities with the concept of one village one product is expected to balance the income between the villages. FMU can promote the research and development to support community to select product for the market. Delivering technology input is expected to improve the production of society's choice.

3. *Determination of benefit-sharing in collaboration*

The community village role in determining the benefit sharing in collaboration with forest commodity production is set through deliberation and consensus between the capital owners and the community. Benefit sharing is a net profit after deducting operational costs and liabilities for the state (Nurfatriani et al., 2015). The benefit-sharing becomes village asset and the capital of Village Owned Enterprises (BUM-Desa). The parties who are involved in the collaboration undertake the management sharing between community, company and FMU of Meranti. The mentioned profit sharing shall be calculated from business income with an agreed portion of profit sharing. The management shall take the following matters into account for distribution of the profit: the profit-sharing portion at least is based on the stipulated tariff; roles and risks are borne by the parties; result of the agreement between the community, company and FMU and realization of benefit. The agreements are achieved through a participatory and transparent process. If the income is below the specified target, the results are prioritized to compensate for all the expenditures of the capital owner, and if any
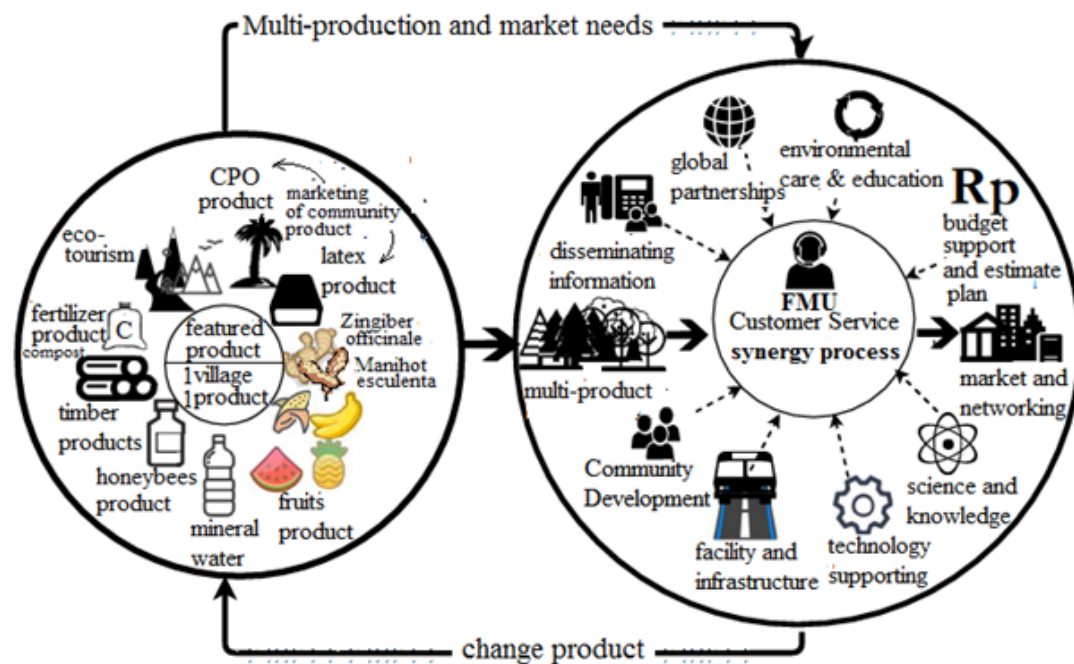
Figure 6. Synergizing between the community's agricultural products and the market

income is remaining, the parties receive profit sharing proportionally already set, and the income sharing also considers the sustainability of forest management. Hereafter, if the value of income sharing has been fulfilled, the parties can extend or terminate the cooperation agreement, and the assets such as buildings and equipment or machinery will belong to the village.

F. Implementation of Villages Institutionalization

Synergizing the implementation of activities between the community's agricultural products and the market in the concept of one village one product to meet market needs is done dynamically. Products have variations according to market demand. The role of FMU as the provider of information or customer service for villagers shall provide information regularly based on market needs. Synergy of activities is coordinated by FMU through creatively combining communication science and technology. Synergizing between the community's agricultural products and the market is shown in Figure 6.

Collaboration is the involvement of all teams in efforts to optimize forest management. Effective collaboration could be materialized if there are cooperation, appreciation of local knowledge, knowing the needs, concerns and beliefs among all parties (Di Gregorio et al. 2017; Nurrochmat et al. 2016). Collaboration could be successful if it has one vision in mind, activities and find the effective action through developing new ideas. To be successful in collaboration requires professionals, technologies, machines, and best quality seeds to get optimal results. All parties involved must understand that if one part fails that is the failure of all parties. CCA-FM is a model that involves all parties in forest management and village position as managerial unit in areas claimed by the community. The function of FMU has changed to provide technical support and knowledge, and control of state revenue (PNBP). Collaboration between companies and communities can use budgeting as capital assets.

The role of extensions in the field should be increased in capacity to provide input for the community. The development of CCA-FM
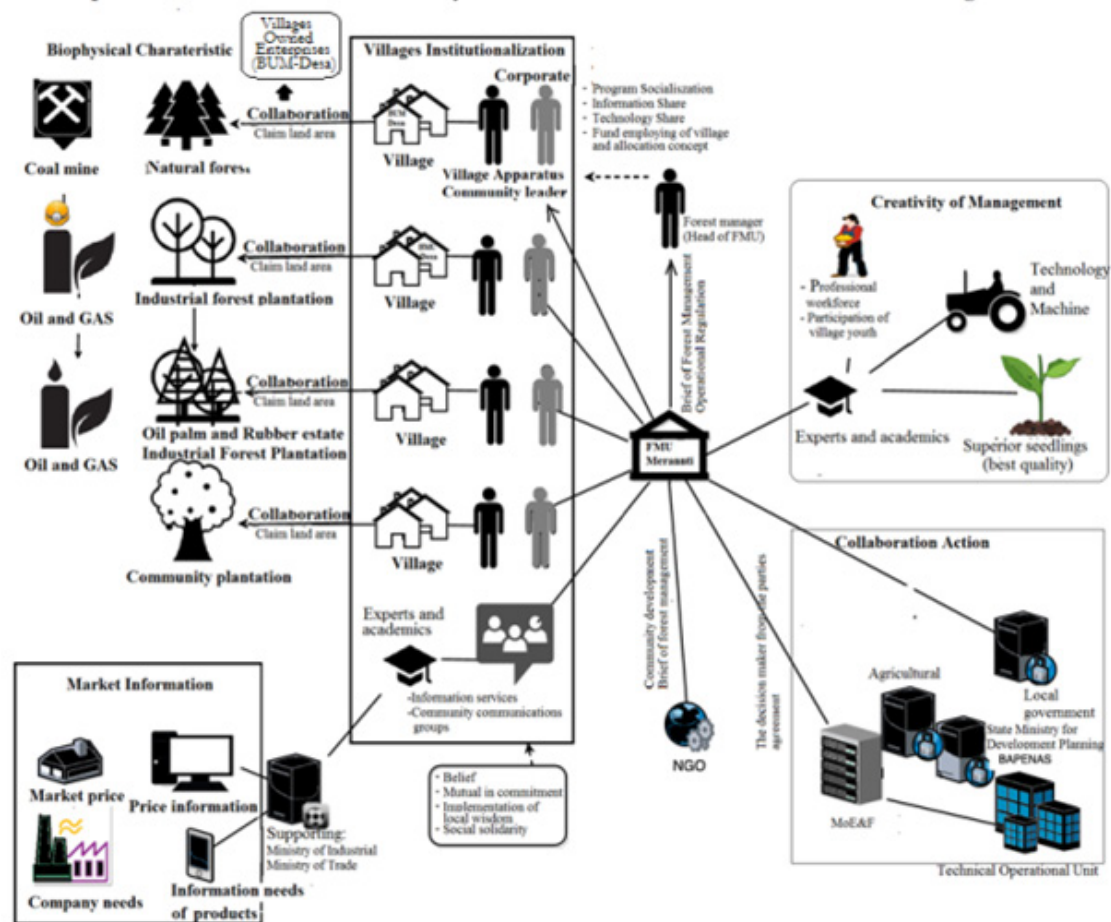
Figure 7. A concept of conflict resolution using CCA-FM

in FMU Meranti continues to be conducted with various cultivation of various commercial valuable crops with the collaboration of all parties. The creativity of FMU head is urgently needed to convince the public and the company to collaborate on the claimed land in accordance with the community without coercion. This is necessary to provide awareness for the local elite who is fanatic to the specific kind of crops such as oil palm and rubber. FMU and companies provide technical support and knowledge, and open markets. Dissemination of information and technology is delivered through extension which is close to the community and provide training for the village youth. A concept of conflict resolution using CCA-FM is shown in Figure 7.

Model Creativity and Collaboration Action-Forest Management (MCCA-FM) has been

implemented in FMU Meranti. The form of collaboration between FMU and community villages in developing area planting, i.e.: *Peronema canescens* (sungkai), *Neolitsea javanica* (kalimuru), *Zingiber officinale* (jahe merah), *Zea mays* (jagung), and *Manihot esculenta* (ubi kayu). Furthermore, they also developed livestock (goat and cow). Another business is buying and selling plant seeds and natural fertilizers. Plots of working area in five locations are shown in Figure 8. The process of MCCA-FM implementation in the field is shown in Table 1 and Figure 9.

IV. CONCLUSION

Institutionalization of villages as an alternative solution to resolve forest area utilization conflict could be implemented in FMU Meranti. The local elites who have one vision need to be embraced to participate

Table 1. MCCA-FM Implementation

MCCA-FM Program	User	Areas (hectares)
Creativity		
Land allocation	Community groups and individuals in specific area (FMU Managed area)	35,641.00
Technology **Plant seeds - fertilizers business**	Mr Suparno and colleagues related to business collaboration on selling and buying plant seeds and fertilizers with target 2 ton per month	
Developing area plantation		
Kalimuru *(Neolitsea javanica)* and Water Melon	Kalimuru Co. (partnership) Community village in surrounding forest (*Pangkalan Bulian* Village)	20.00
Sungkai *(Peronema canescens)*	*Sakosuban* Village	5.00
Jahe Merah *(Zingiber officinale)*	Mr Alex (BBP Co.) and community village in surrounding forest (*Simpang Bondon* Village)	16.00
Ubi Kayu *(Manihot esculenta)*	Community groups *Pangkalan Bayat* Village Community groups *Pagar Desa* Village	active active
Jagung *(Zea may)*	Community groups *Pangkalan Bayat* Village Community groups *Bintialo* Village Community groups *Bayat Ilir* Village Community groups *Pagar Desa* Village	active active active active
Development livestock i.e.: Goat and cow	Community *Bayat Ilir* Village *Pangkalan Bayat* Village	active in process
Collaboration		
Rubber plantation	Pinago Utama Co (active)	1,300.00
Sungkai *(Peronema canescens sp.)*	SBB Co.	120.00
Oil Palm plantation	SSB Co PAL Co. PTPN VII Co.	in process in process in process

together with creative and collaborative action in forest management. Their existence is expected to change behaviour of other elite for solving the problems of forest management. Facilitating multi-ethnic collaboration actions are needed in reducing elite domination, so local elite will not be dominating which has occurred in many areas where they gained from their symbolic power.

MCCA-FM is the best solution to prevent conflict in utilization of land inter parties in FMU Meranti because this model can compose the community's creativity and FMU manager creativity to increase the community's economy and forest management sustainability. It has been implemented in a small scale in FMU Meranti (5 locations) by collaborating with all parties. The result showed that communities and village administrators fully support the MCCA-FM. Therefore, it needs to be developed in other location too.

It is recommended that the choice of government decisions does not ignore the biophysics attribute and existing community as user in forest area, the existing community activities are facilitated by granting the community forest permit and the collective action need to encourage community activities and FMU manager activities more creatively.
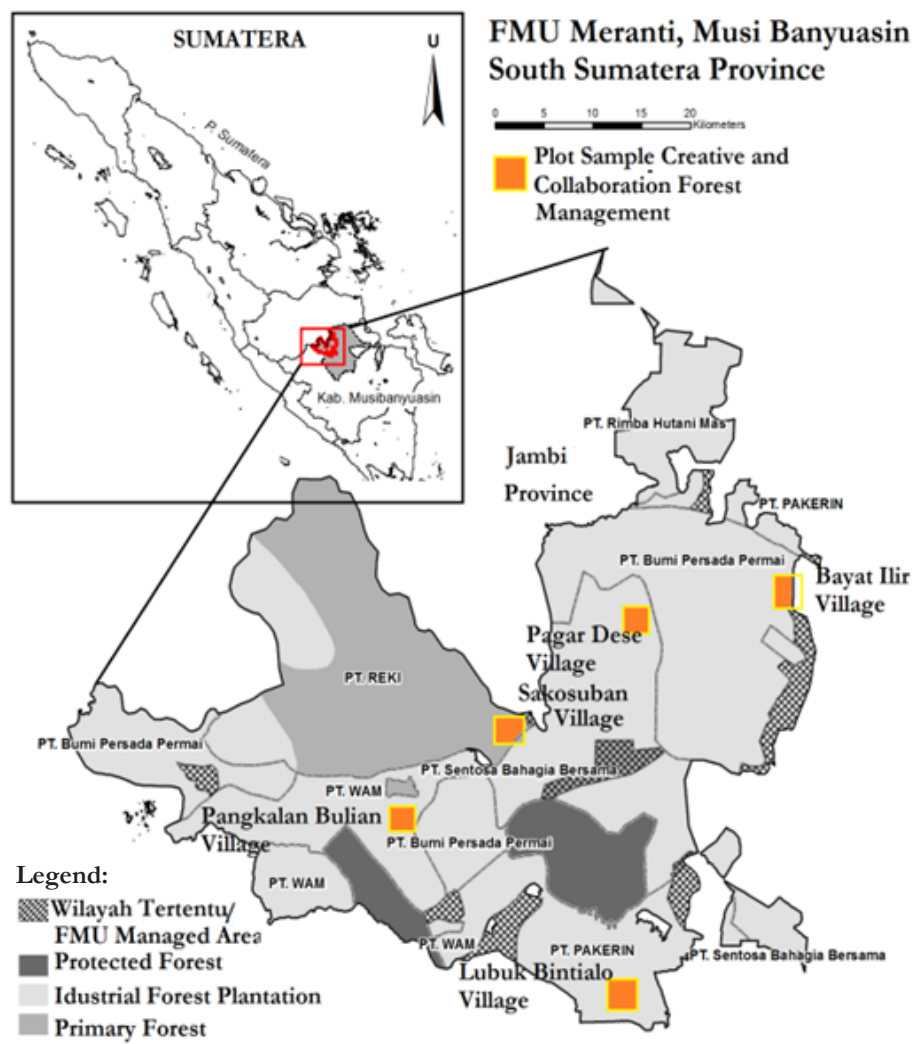
Figure 8. Implementation area of MCCA-FM

Figure 9. Implementation in business collaboration of *Zingiber officinale*

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GROWTH PERFORMANCE OF THREE NATIVE TREE SPECIES FOR PULPWOOD PLANTATION IN DRAINED PEATLAND OF PELALAWAN DISTRICT, RIAU

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GROWTH PERFORMANCE OF THREE NATIVE TREE SPECIES FOR PULPWOOD PLANTATION IN DRAINED PEATLAND OF PELALAWAN DISTRICT, RIAU. The productivity of exotic species developed in pulpwood plantations in Indonesia (HTI-pulp) has been continuously decreasing. On the other side, there is a possibility to develop several promising native tree species in peatland HTI-pulp plantations. However, less information is available on the performance of those native tree species for planting in peatland pulpwood plantation. This study evaluates the performances (survival rate, growth and yield) of three native trees [mahang (*Macaranga pruinosa)*, skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*)] in drained peatland, in terms of suitability for pulpwood plantation. An experiment plot was established by planting three native tree species and krasikarpa (*Acacia crassicarpa*) in drained peatland at Pelalawan District, Riau. Survival, growth and yield variables were monitored frequently until 5.5 years after planting (YAP) and then were analyzed. Geronggang (survival rate = 80.0%) and mahang (survival rate = 65.6%) showed good survival rates at 5.5 YAP which were significantly ($p<0.05$) higher than that of krassikarpa (22.4%). Geronggang and mahang are relatively promising growth and yield in which height, diameter and yield increment until 5.5 YAP were 1.96 m/year and 2.31 m/year; 2.08 cm/year and 2.59 cm/year; 13.1 m^3/ha/year and 21.4 m^3/ha/year, respectively. Yet, those growths and yields were still significantly ($p<0.05$) lower than those of krasikarpa, probably due to unequal seedling quality. These results indicated the potential of mahang and geronggang to be developed in peatland pulpwood plantations. However, tree improvement program is necessarily required for mahang and geronggang to initiate the development.

Keywords: Native tree species, pulpwood plantation, drained peatland, seedling quality

PERTUMBUHAN TIGA JENIS POHON LOKAL UNTUK DIKEMBANGKAN PADA HTI-PULP LAHAN GAMBUT YANG DIKERINGKAN DI PELALAWAN, RIAU. Produktivitas jenis pohon eksotik yang dikembangkan di HTI-pulp di Indoneisa terus menurun. Sementara itu, beberapa jenis pohon lokal mempunyai potensi untuk dikembangkan sebagai tanaman HTI-pulp. Akan tetapi, informasi mengenai performa jenis pohon lokal tersebut belum tersedia dengan memadai jika secara khsusus akan dikembangkan di HTI-pulp. Penelitian ini dilakukan untuk mengevaluasi performa (kemampuan hidup, pertumbuhan dan hasil) tiga jenis pohon lokal lahan gambut [mahang (Macaranga pruinosa), skubung (Macaranga gigantea) dan geronggang (Cratoxylum arborescens)] yang berpotensi untuk dikembangkan di HTI-Pulp. Sebuah plot penelitian dibangun di lahan gambut yang dikeringkan di Pelalawan, Riau; dengan menanam ketiga pohon lokal tersebut dan ditambah jenis eksotik krasikarpa. Pengamatan dan analisis data dilakukan terhadap variabel kemampuan hidup, pertumbuhan, dan hasil dalam kaitannya untuk bahan baku pulp. Hasil penelitian menunjukkan bahwa geronggang (persen hidup 80%) dan mahang (persen hidup 65,6%) memiliki kemampuan hidup yang baik sampai pada umur 5,5 tahun dan secara nyata (p<0,05) lebih baik dibandingkan krasikarpa (persen hidup 22,4%). Pertumbuhan dan hasil kedua jenis ini pun sampai pada umur yang sama relatif baik, dengan riap tinggi 1,96 dan 2,31 m/tahun, diameter 2,08 dan 2,59 cm/tahun dan hasil 13,1 dan 21,4 m³/ha/tahun. Akan tetapi, pertumbuhan dan hasil tersebut secara signifikan (p<0,05) masih lebih rendah dibandingkan pada krasikarpa, diduga karena adanya perbedaan kualitas bibit. Hal ini mengindikasikan bahwa mahang dan geronggang merupakan kandidat kuat untuk dikembangkan pada HTI-pulp di lahan gambut. Namun, untuk sampai pada tahap pengembangan, program pemuliaan terhadap kedua jenis pohon lokal tersebut harus dilakukan.

Kata kunci: Jenis pohon lokal, bahan baku pulp, lahan gambut didrainase, kualitas bibit

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I. INTRODUCTION

Indonesia has large areas of industrial plantation forests (HTI) which have been dominated by pulpwood plantations (HTI-pulp). Until 2015, the total area of HTI was around 2.1 million ha and about 1.8 million ha (88%) was HTI-pulp (Ministry of Environment and Forestry, 2016). This HTI-pulp is the main supplier of the wood to pulp and paper industries, whereas Indonesia is one of the largest producer of pulp and paper in the world. The Ministry of Industry (2016) reported that the production of pulp and paper in Indonesia until 2013 was 4.55 million ton (number 9th in the world) and 7.98 million ton (number 6th of the world), respectively.

The Government of Indonesia has made various efforts to increase the production of pulp and paper. However, these efforts have been facing the declining trend in the productivity of HTI-pulp including ones that were established in peatland of Riau. It gets serious concern because Riau is one province in Indonesia with the largest area of HTI-pulp, i.e. approximately 800 thousand ha and over 50% of it is in peatland (Ministry of Environment and Forestry, 2016).

Krasikarpa (*Acacia crassicarpa*), one of an exotic tree, is the only species of acacia that grows well in peatland it had been developed in the peatland HTI-pulp over the years. However, the performance of this exotic species in HTI-pulp shows a declining trend as plant rotation is progressing. The survival rate and yield of krasikarpa in the second and upward rotations were relatively low i.e. below 30% and 140 m³/ha at 5 years (Nurcan, Refdanil, Sribudiani, & Sudarmalik, 2014; Suhartati, Rahmayanto, & Daeng, 2014).

Diseases were suggested as one of the main causal factor in the declining performance of krasikarpa. The root disease by *Ganoderma* spp. and wilting caused by *Ceratocystis* spp. were suspected as the main diseases in krasikarpa (Rimbawanto, 2014; Tarigan, Roux, Wyk, Tjahjono & Wingfield, 2011). The efforts to overcome this decline in productivity of the exotic species showed no promising results; therefore it is required to explore other tree species to be developed in peatland HTI-pulp. Then, it is reasonable to explore peatland native tree species. These native trees must be already well adapted with the peatland conditions and surely could grow. The exotic species in several cases were even better than exotic species (Bare & Ashton, 2015; Farias et al., 2016; Nath, Schroth, & Burslem, 2016; Onefeli & Adesoye, 2014).

Yet, other studies showed opposite results and it was noted that tree performance of native species is lower than that of exotic species (Kawaletz et al., 2013; May, 2016; Junaedi, 2018). Nevertheless, there is little information on survival rate and growth of native tree species in regard to specific purpose for pulpwood plantation. Most studies on native tree species growth performance in peatland had focused on broader purposes, such as for reforestation, restoration or rehabilitation (Astiani, Burhanuddin, Curran, Mujiman, & Salim, 2017; Banjarbaru Research Institute, & Graham, 2014; Lampela, Jauhiainen, Sarkkola, & Vasander, 2017; Rotinsulu, Indrayanti, & Sampang, 2016; Tata & Pradjadinata, 2016). Therefore, it is necessary to study the survival rate and growth characteristics of some native species of peatland that will be promoted for pulpwood plantation.

This paper evaluates the performance (survival rate, growth and yield) of three native tree species namely mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*), which will be promoted for pulpwood plantation in peatland. All of the three species have been naturally found in peat forest and also peatland around Riau area (Blackham, Webb, & Corlett, 2014; Lim, Lim, & Yule, 2014; Nurulita, Adetutu, Gunawan, Zul, & Ball, 2016; Suhartati, Rahmayanti, Junaedi, & Nurrohman, 2012). Those tree species were selected as they are pioneer species which are fast growing and moreover, its fiber is relatively

good in quality as pulp raw material (Aprianis, 2016). Krasikarpa as the exotic species has been included in the study for comparation.

II. MATERIAL AND METHOD

A. Site Description

The study was conducted in the Community Forest Lubuk Ogong Village, Pelalawan District, Riau Province (101°41'06"–101°41'10" E, 0°19'42"–0°19'48" N and 12 m asl), about 26 km from Pekanbaru, the capital of Riau Province. The soil type is peat (histosol) with maturity was dominated by fibric–hemic. Peatland in the location was drained to a water table level that was about 20–135 cm below surface depending on the season (rainy or dry) (Husnain et al., 2014). The climate was type A with a daily temperature range of 21°–32°C and annual precipitation of 2,500–3,000 mm (Husnain et al., 2017).

B. Plot Establishment

Three native tree species of peatland were selected for the experiment: mahang (*Macaranga pruinosa*), skubung (*Macaranga gigantea*) and geronggang (*Cratoxylum arborescens*). One exotic species krasikarpa (*Acacia crassicarpa*) was also included in this study. Seedlings of the selected native tree species were obtained from wildlings because there was still lack of technique on generative propagation of these species. Mahang wildlings were obtained from secondary peat forest in Siak District, Riau. Geronggang wildlings were obtained from secondary peat forest in Bengkalis District, Riau. However, skubung wildlings were obtained from community land, especially around rubber plantation because they could not be gathered from the peat forest. In contrast, seedlings of krasikarpa originated from the tree improvement program of PT. RAPP nursery (Papua New Guinea Provenance). All planting materials (wildling and seedling) were prepared in 2010.

A randomized block design was used as experimental plot design in approximately 1 ha of area. There were 5 blocks as replications and each block was divided into 4 rectangular sub-blocks to provide 4 tree species: 3 native that were mahang, skubung, geronggang and one exotic that was krasikarpa. Following the randomized block design, the four selected species were then planted onto each designed sub-block. Each sub-block consist of 7 rows x 7 columns thus each sub-block has 49 trees of one selected species. Therefore, there were 245 seedlings of each species or totally 980 seedlings for all selected species.

Land preparation was conducted with machinery, subsequently similar silviculture treatments that is commonly used in PT. Riau Andalan Pulp and Paper (RAPP) were applied to all tree species, except for weed control. These treatments were: plant spacing of 2 x 3 m; fertilizing during planting and consisting of rock phosphate/$Ca_3(PO_4)_2CaF$ (250g/seedling), KCl (50 g/seedling), ertibor/$Na_2B4O_7 \cdot 5H_2O$ (10 g/seedling) and zincop/$ZnSO_4.H_2O$ & $CuSO_4.7H_2$ (10g/seedling); pruning was done six months after planting; monthly tree blanking until 1 year; while weed control (manual removal) was carried out three monthly until 2 years for native species and until 1 year for krasikarpa. Land preparation and subsequent plantation were conducted until the end of 2011 (October–November 2011).

C. Measurements

Variables that express the survival rate and growth performance were measured in this study. The number of alive individuals (n), height (Ht), base diameter (Db), diameter at breast height (DBH) and crown diameter (Crw). The n, Ht, Db and DBH were measured six monthly during 1–3.5 years after planting and then annually until 5.5 years after planting. The Ht was measured using measuring stick, while Db, DBH and Crw were measured by measuring tape.

The value of form factor (*f*) is required to quantify the wood volume (yield) of each species. In order to obtain the *f* value, tree diameter at 10 cm height from the soil surface

up to the height where the diameter was 5 cm was measured in one meter intervals, in terms of pulpwood. This measurement was conducted on selected trees at 4.5 and 5.5 years after planting. The number of trees measured for each species at 4.5 years after planting were mahang (29 trees), skubung (29 trees), geronggang (29 trees) and krasikarpa (5 trees); while at 5.5 years after planting 3 trees for all native species and 1 tree for krasikarpa. These diameter sections data were used to quantify the actual yield (wood volume) for pulpwood for each species.

D. Data Analysis

The data on alive individual tree of each species were used to quantify the survival rate (Sv) of each species as a percentage of trees that were planted. Basal area and crown diameter were calculated based on Aisah, Yusop, Noguchi, and Rahman, (2012) as follows:

Basal area (m²/ha) $= \pi.(DBH/2)^2$...................(1)

Crown area (m²) $= \pi.(Crw/2)^2$...........................(2)

where: $\pi = 3.146$; DBH = diameter at breast height (m) and Crw = Crown diameter (m)

The yield or wood volume of each species for pulp raw material were calculated using the formula as mentioned by Masota, Malyango, Zahabu, Malimbwi & Eid, (2014):

Volume per tree (Vi, m³/tree) $= 0.25.$ $\pi.(DBH)^2.Ht.f$ ....(3)

where: $\pi = 3.146$; Ht = Total Height (m), f = form factor for pulpwood ($f = Va/Vs$, $Va =$ actual yield for pulpwood that was calculated using Smalian Method, $Vs =$ cylinder volume with surface area based on dbh and length based on Ht)

Volume per ha (V, m³/ha) $= Vi. D_0 . Sv.$ ......(4)

where: $D_0 =$ initial seedling density (n/ha) and $Sv =$ Survival rate

One-way analyses of variance (ANOVA) were performed to test the difference among species in survival rate and growth. The Duncan test was applied to test those variables to determine the statistical difference of the mean of survival rate and growth. Prior these analyses data transformation was performed on several data that had not met ANOVA assumption (The normality and homogeneity of variance).

III. RESULT AND DISCUSSION

A. Survival Rate and Growth

The survival rate of tree species was significantly different ($p < 0.05$). Overall, after 5.5 years planting, two native species (mahang and geronggang) showed noticeably high survival rates (Sv>60%) and were significantly ($p < 0.05$) higher than the exotic tree (Sv of krasikarpa <30%). The survival rate of skubung was relatively similar ($p > 0.05$) to that of krasikarpa (Figure 1).

The highest survival among native species until 5.5 YAP was presented by geronggang (Sv = 80.0 %), although it was not statistically different ($p > 0.05$) from mahang (Sv = 65.6 %). Geronggang also showed a conspicuously stable survival rate, while the survival of mahang and skubung sharply declined 4.5 YAP. Earlier mortality and higher decline of survival was revealed in krasikarpa compared to those of the native species. Krasikarpa exhibited Sv >80% at 2 YAP, but subsequently continued to reduce and by the 3rd YAP, the survival declined to 22.4 %.

Overall, significantly different growth ($p < 0.05$) was observed within the tested species. The growth of the exotic species krasikarpa was significantly ($p < 0.05$) better than those of the native species and this trend continued to increase with increasing stand age. In general, the best growth performance among the native species was for mahang despite it was not significantly ($p > 0.05$) different from geronggang (Figure 2).

The growth rate of krasikarpa was decreasing during 1.5–5.5 YAP that was shown by the decreasing height and DBH increment as the age was increasing (Figure 3). In contrast, the growth rates of the native tree species were relatively more stable. However, the growth rate
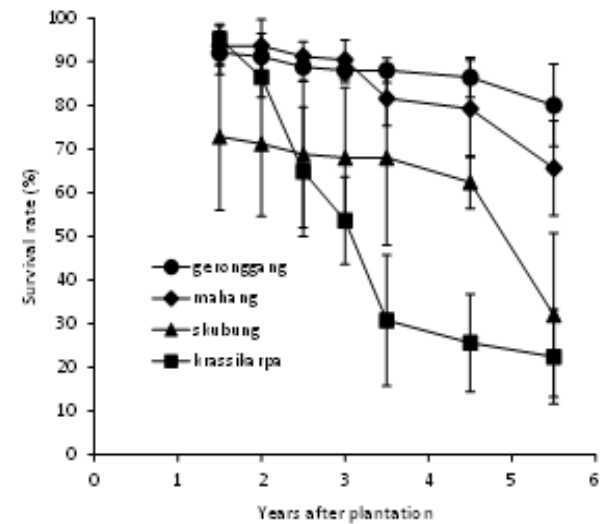
Figure 1. The survival rate of three native tree species and krasikarpa (exotic species) observed until 5.5 years after plantation (YAP) in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)
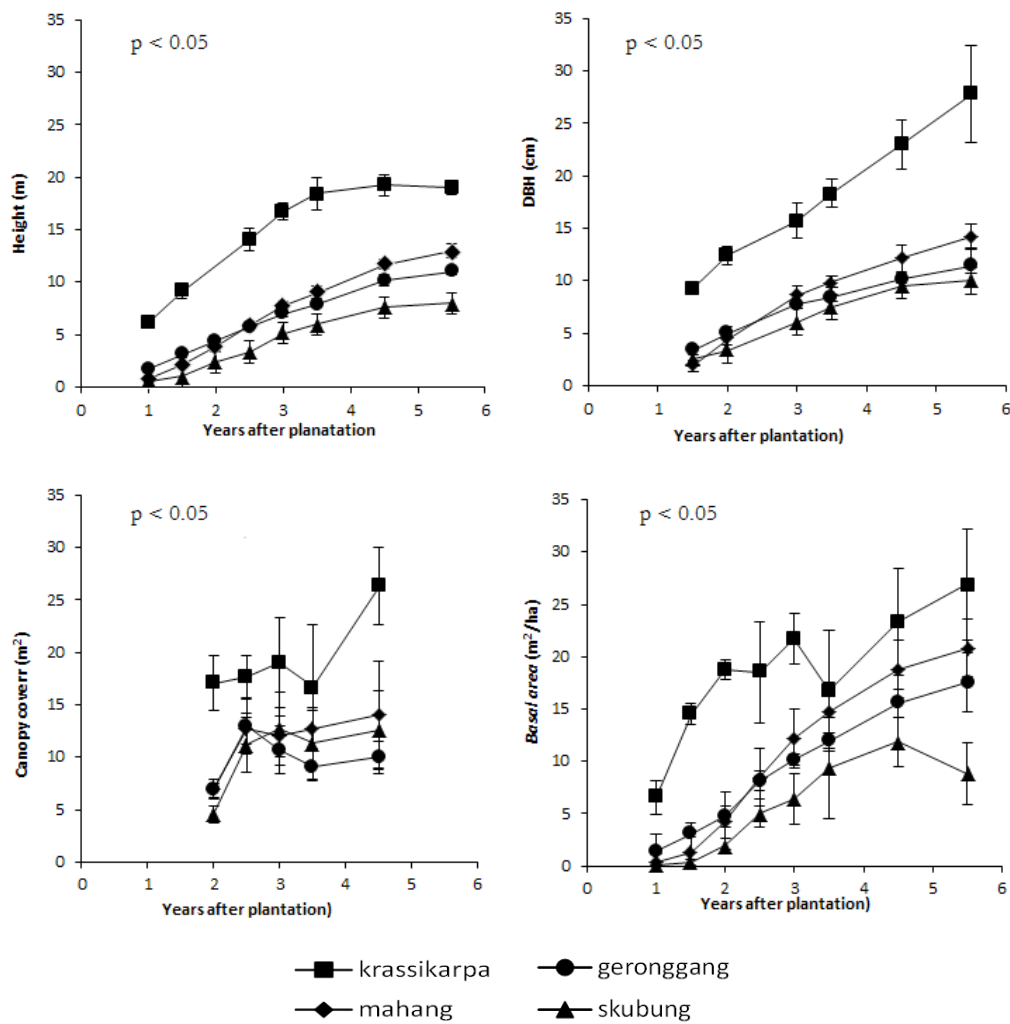

Figure 2. The growth of three native tree species and krasikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)
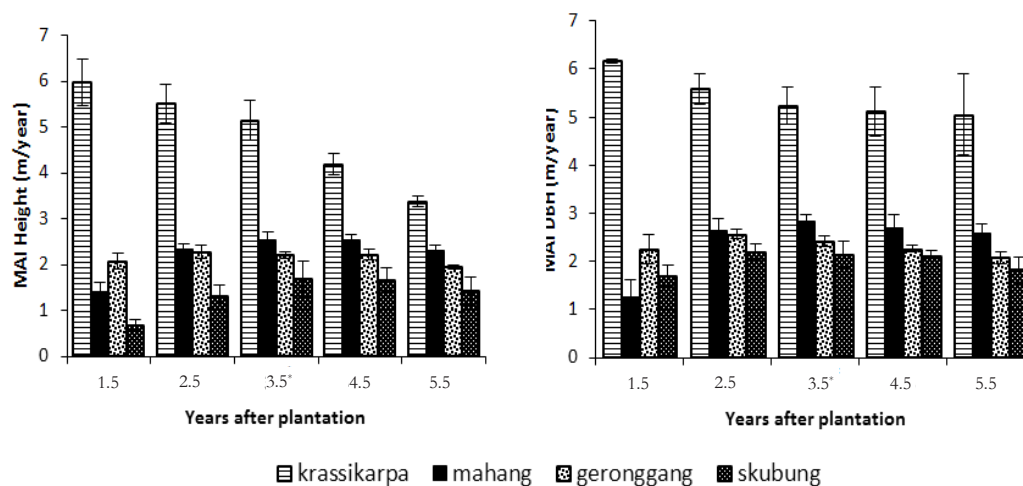
Figure 3. The growth increment of three native tree species and krassikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5).

[*]=Source: Junaedi (2016)

of krasikarpa during the observation was still significantly (p<0.05) higher than all the three native species. The growth rate of height and DBH of krasikarpa at 5.5 YAP (Ht = 3.38 m/year and DBH = 5.05 cm/year) was 1.46 and 1.95 times faster than those of the best native species which was mahang (Ht = 2.31 m/year and DBH = 2.59 m/year). Among the native tree species, the height of mahang at 5.5 YAP was growing 1.2 and 1.6 times faster than that of geronggang (Ht = 1.96 m/year) and skubung (Ht = 1.42 m/year), respectively; while for DBH it was 1.2 and 1.4 times faster than that of geronggang (DBH = 2.08 cm/year) and skubung (DBH = 1.82 cm/year), respectively.

B. Yield

In general, the best wood volume and MAI among the observed native tree species until 5.5 YAP was obtained in mahang. The wood volume (117.9 m³/ha) and its MAI (21.4 m³/ha/year) of mahang was significantly (p < 005) higher than that of geronggang (V = 72.1 m³/ha and MAI = 13.1 m³/ha/year) and skubung (V = 20.9 m³/ha and MAI = 3.8 m³/ha/year) at 5.5 YAP (Figure 5). However, the wood volume of mahang was significantly lower than that of krasikarpa. The wood volume of krasikarpa

was 4.7 and 1.4 fold higher than mahang for wood per tree and stand volume, respectively (Figure 4).

This study on growth performances of three native species was focused on the purpose to obtain the candidate of native tree species to be grown on peatland of HTI-pulp. The wood in HTI-pulp in general have been harvested at 4–5 YAP (Suhartati et al., 2013). The data on growth performance and yield of the native tree species in this study was measured until 5.5 YAP, therefore, the data of this study should be sufficient to assess the feasibility of native trees for HTI-pulp. This was also supported by the curves of MAI (wood volume) and CAI (wood volume) of each species (Figure 5). The MAI and CAI curve of skubung and krasikarpa were intersected at 5 YAP and below 6 YAP for mahang and geronggang (Figure 5).

As the performance of exotic species in HTI-pulp has been declining, there were great expectations on the performance of native tree species in this study. The expectation was fulfilled by the higher survival rate of all native tree species than that of krasikarpa (exotic species). This result is in accordance with some prior studies that native tree species had better survival rate than exotic tree species (Farias
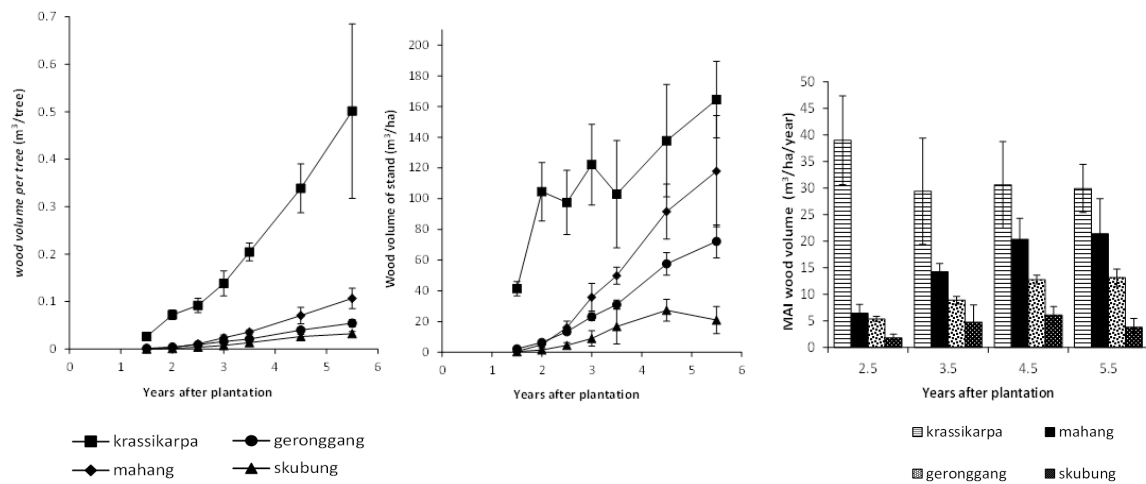
Figure 4. Wood volume (m³/tree and m³/ha) and MAI (m³/ha/year) of three native tree species and krassikarpa (exotic species) observed until 5.5 YAP in drained peatland of Pelalawan, Riau (data = mean ± Sd, n = 5)
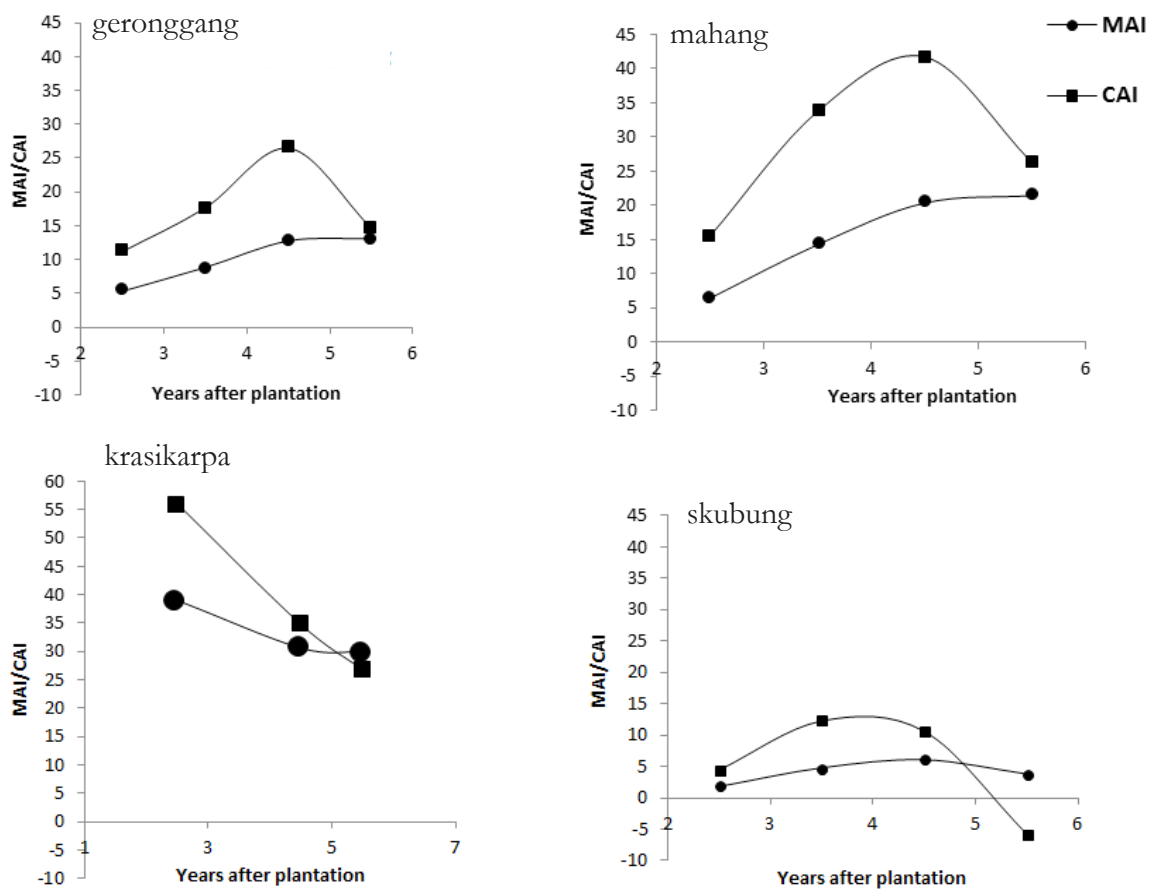
Figure 5. The curve of MAI (wood volume, m³/ha/year) and CAI (wood volume, m³/ha/year) of three native tree species and krassikarpa (exotic species) planted on drained peatland of Pelalawan, Riau

Figure 6. The symptoms of dieback on skubung and mahang planted in drained peatland of Pelalawan, Riau

et al., 2016; Lampela et al., 2017; Subiakto, Rachmat, & Sakai, 2016). Regardless, this study found that in terms of survival rate, geronggang is the most promising native tree species for HTI-pulp. This tree had the highest survival rate which was relatively stable until 5.5 YAP. This result confirmed the study of Mojiol et al. (2014) in peatland of Sabah, Malaysia, which found the best survival rate of geronggang.

The high survival rate of geronggang was presumably because this native tree was not prone to attacks of pests and diseases. In contrary, mahang and skubung suffered rather high tree mortality caused by attack of diseases, particularly at 5.5 YAP. The attack was indicated by dieback symptoms on those two native tree species that was particularly occurring in skubung with survival rate of <40% at 5.5 YAP (Figure 6). However, this study did not conduct specific observation on pests and diseases thus the exact diseases that attacked the plants yet to be identified.

Based on visible symptoms observed in the field, it was suspected that most mortality occurred in krasikarpa (exotic species) was related to pest and disease attack as well. The symptoms were visibly clearer on krasikarpa than on the native species (Figure 8). This indicated the higher susceptibility of the exotic species (krasikarpa) to pest and disease attack than those of the native tree species. The result was similar with other studies in which several species were more severely prone to pest and disease attack when they were planted outside their natural range, such as in *Acacia* spp., *Eucalyptus* spp., and poplar (Herath et al., 2016; Wingfield, 2003).

Although the study did not carried out specific analysis to identify the disease, but the signs and symptoms observed in the field indicated that the mortality of krasikarpa may strongly be related to attacks of *Ganoderma* sp., *Ceratocystis* sp. and termite (Figure 7). The signs of *Ganoderma* sp. and termite attacks were evidently observed in the field, while *Ceratocystis* sp. attack was assumed based on the symptoms e.g. lesion and the discoloration around the bark, xylem and cambium (de Beer, Duong, Barnes, Wingfield, & Wingfield, 2014; Rahayu, Nurjanto, & Pratama, 2015; Tarigan et al., 2011) (Figure 7). Several studies were also reported the attacks of *Ganoderma* sp., *Ceratotocystis* sp. and

Figure 7. The signs and symptoms of pests and diseases attacks on krasikarpa in drained peatland of Pelalawan, Riau

Remarks: a = The body of presumed *Ganoderma* sp., b = termites, c = discoloration, d = lesion

termite on acacias around the world (Francis et al., 2014; Haggar, Briscoe, & Butterfield, 1998; Tarigan et al., 2011).

However, in term of survivorship of the native tree species is better than that of krasikarpa was not followed by equally better growth and yield performance. The growth and yield of krasikarpa was superior to those of the tested native tree species. Yet, the growth comparison between the natives and the exotic was actually rather unjust considering the krasikarpa used in this study was developed from tree improvement program while the natives were from wildling/unimproved seedlings. Comparison on growth and yield of the natives with those of the supposedly unimproved krasikarpa demonstrated less gap of growth between the two tested objects. The height and DBH increment of the supposedly unimproved krasikarpa were 2.8 m/year and 3 cm/year at 1.6 YAP (Cole, Yost, Kablan, & Olsen, 1996), which were not ominously different from those of mahang and geronggang in this study (Figure 3).

The growth performance displayed by mahang and geronggang qualifies them as fast growing species. Growth of other native tree species were reported by several previous studies (Table 1) as comparison to those two tested species. Therefore, this study is then promoting mahang and geronggang as the candidates of native tree species to be grown in peatland of HTI-pulp, but tree improvement program to enhance the growth quality of the seedlings is a prerequisite. For instance, tree improvement program had been successful to improve the yield of *Eucalyptus* spp. in Brazil from 10–17 m^3/ha/year to 25–70 m^3/ha/year (Gonçalves et al., 2013; Leksono, 2016). It is highly possible to achieve the same success result as of eucalypt in Brazil with geronggang and mahang in peatland that without tree improvement the yield of geronggang and mahang reached 13.1 m^3/ha/year and 21.4 m^3/ha/year, respectively (Figure 6).

Geronggang as a matter of fact has more potential than mahang for peatland HTI-pulp. Geronggang displayed the best and more

Table 1. The growth performances of several native tree species planted around tropical area

No.	Species	Height growth (m/year)	DBH growth (cm/year)	Locations	References
1.	*Shorea balangeran*	0.23 – 1.62	0.78 – 2.41	Kalimantan (Peatland)	Hilwan, Setiadi, & Rachman, (2013) & Lampela et al. (2017)
2.	*Parashorea smythiesii*	0.49 – 2.40	0.87 – 3.97		
3.	*Shorea leprosula*	0.9	1.4	Riau, Indonesia (Peatland)	Subiakto et al. (2016)
4.	*Dacryodes rostrata*	0.12	-	Kalimantan, Indonesia (Peatland)	Lampela et al. (2017)
5.	*Sterculia* sp.	0.1			
6.	*Terminalia microcarpa*	1.18	1.42		
7.	*Ochroma pyramidae*	0.42	1.92	Mexico (Dryland)	Da˜nobeytia et al. (2015)
8.	*Alnus acuminiata*	0.95	1.81	Columbia (Dryland)	Bare & Ashton (2015)
9.	*Alstonia scholaris*	0.6	-	Kalimantan, Indonesia (Dryland)	Mawazin & Susilo (2016)
10.	*Khaya anthotecha*	1.22	-	Tanzania (Dryland)	Muiambo (2016)
11.	*Artocarpus hispidus*	1.3	3.2	Malaysia (Dryland)	Yamada, Watanabe, Okuda, Sugimoto, & Azlin (2016)
12.	*Artocarpus altilis*	2.3	2.3		

stable survivorship and it was also not prone to pest and disease thus good productivity and sustainability of HTI-pulp can be expected. In addition, cultivation activity in peatland is regulated by the Government of Indonesia and it declares that only peatland with a water table depth of <40 cm below the surface is permitted for plant cultivation (Indonesian Republic, 2016). Although the depth of water table in the study site is not always below 40 cm, but it occasionally could reach 20 cm below the surface especially in wet season (Husnain et al., 2014) and geronggang could survive at that level of water table although further research on this matter is required. Therefore, the higher and more stable survivorship of geronggang, as well as its possible ability to adjust to lower water table, has made this species a better candidate for peatland HTI-pulp than other tested native trees. Moreover, the wood consumption of geronggang (4.83 m³ wood/ton pulp) for pulp production is lower than that of mahang (6.49 m³ wood/ton pulp) (Aprianis, 2016). It indicates a lower cost for geronggang

than that for mahang on wood transportation from forest to factory and also pulp processing.

Skubung showed the poorest survivorship and growth among the tested species. However, other study noted the promising growth of skubung that was planted in dry land (ultisol), with height and DBH increments of 1.9–3 m/year and 2.2–3.8 cm/year, respectively (Amirta et al., 2016; Susanto et al., 2017). It was reported that skubung naturally can be found not only in peatland but also in dry land (Lim et al., 2014; Raphael, Yan, Yap, & Tan, 2015; Suhartati et al., 2012). Therefore, skubung is more recommended to be planted in dry land than peatland.

IV. CONCLUSION

This study increased the availability of species-specific information on the suitability of three native tree species [mahang (*Macaranga pruinosa)*, skubung (*Macaranga gigantea)* and geronggang (*Cratoxylum arborescens*)] to be grown in pulpwood plantation in peatland; regarding the survival, growth and yield

performances. In the selection of the three native tree species for that purpose, the study also included other aspects into consideration such as the volume of wood consumption in pulp manufacturing, the government regulation and the pulpwood plantation sustainability. Based on the study results, the promising native species were mahang and geronggang, Nonetheless, the promising performances has not made mahang and geronggang feasible to be directly developed in real plantation. The growth performance of those two natives were still lower than that of krasikarpa, therefore, tree improvement program in order to optimize growth and yield performances of mahang and geronggang is strongly recommended prior the development of those native trees as pulpwood plantations in peatland HTI-Pulp.

ACKNOWLEDGEMENT

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ANTIOXIDANT ACTIVITY AND TOXICITY EFFECT OF ELEVEN TYPES OF BARK EXTRACTS ACQUIRED FROM EUPHORBIACEAE

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ANTIOXIDANT ACTIVITY AND TOXICITY EFFECT OF ELEVEN TYPES OF BARK EXTRACTS ACQUIRED FROM EUPHORBIACEAE. The use of natural antioxidants for medicinal purposes deserves thorough attention for their efficacy and possibly adverse toxicity. This paper studies the antioxidant actions and toxicity effects of bark extracts. The study focuses on eleven tree species of Euphorbiaceae family. Initially, bark samples from those trees were extracted using ethanol. The acquired extracts were examined for peroxide values with iodometric method. The bark extracts were chemically screened for possible antioxidant-compound contents, i.e. polyphenols, flavonoids, and saponins; and followed by oxidation-reduction test to assess the extract ability in vitro to scavenge free radicals in their standard sources, i.e. 2,2-diphenyl-1-picrylhydrazyl; altogether to determine qualitatively which species origin from bark extracts afforded the most potential as antioxidants. Toxicity test was performed on those bark extracts to assess their safety on living creatures, particularly humans as tried on shrimp larvae by counting their death, using the Brine Shrimp Lethality Test method. Results show that bark extracts of four plant species, i.e. *Acalypha hispida* Blume, *Bischofia javanica* Blume, *Glochidion arboreum* Blume and *Sapium baccatum* Roxb species afforded potentiality as antioxidants, because its peroxide value (POV) was lower than or somewhat above those of the positive control vitamin E (POV 89.45 µg/ml). However, bark extracts from *Euphorbia antiquorum* L, *Euphorbia hirta* L, and *Jatropha podagrica Hook* (i.e. LC_{50} : 238.85; 228.11 & 194.51 µg/ml) were highly toxic, because their LC_{50}'s value< 1000 µg/ml.

Keywords: Bark materials, ethanol extracts, peroxide value, antioxidant activity, toxicity

STUDI AKTIVITAS ANTIOKSIDAN DAN DAYA RACUN EKSTRAK KULIT 11 JENIS TANAMAN FAMILI EUPHORBIACEAE. Penggunaan bahan antioksidan alami untuk keperluan pengobatan perlu memperhatikan kemujaraban dan kemungkinan daya racunnya. Penelitian ini bertujuan mempelajari aktivitas antioksidan dan daya racun ekstrak kulit 11 jenis tanaman dari famili Euphorbiaceae. Awalnya, contoh kulit diekstraksi dengan etanol, dan hasilnya diperiksa bilangan peroksidanya dengan cara iodometri. Pemeriksaan fitokimia pada ekstrak kulit terhadap kemungkinan kandungan antioksidannya, yaitu polifenol, flavonoid, dan saponin; dilanjutkan dengan uji oksidasi-reduksi guna mencermati kemampuan ekstrak memangsa radikal bebas pada sumber baku (2,2-diphenyl-1-picrylhydrazyl/DPPH); guna menentukan ekstrak kulit mana yang paling berpotensi sebagai antioksidan. Eksrak kulit juga diuji toksisitasnya terhadap makluk hidup, khususnya manusia dicobakan pada jentik udang, menggunakan cara Brine Shrimp Lethality Test. Hasil penelitian menunjukkan ekstrak kulit dari empat jenis tanaman, yaitu Acalypha hispida *Blume,* Bischofia javanica *Blume,* Glochidion arboreum *Blume, dan* Sapium baccatum *Roxb berpotensi sebagai antioksidan karena nilai peroksidanya (NP) lebih rendah atau sedikit di atas nilai peroksida kontrol positif vitamine E (NP 89,45 µg/ml). Akan tetapi ekstrak kulit dari* Euphorbia antiquorum *L,* Euphorbia hirta *L dan* Jatropha podagrica *memiliki daya racun yang tinggi (masing-masing: 238,85; 228,11 dan 194,51 µg/ml) karena nilai* LC_{50} < 1000 µg/ml.

Kata kunci: Bahan kulit, ekstrak etanol, bilangan peroksida, aktivitas antioksidan, toksisitas*

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I. INTRODUCTION

The use of natural antioxidant is obtained usually through the extraction from particular portions of plants (e.g. bark, leaves, stems and twigs) and has been developed extensively in current medicines. Depending on the content and kind of their natural compounds in such plant extracts, they have proven their efficacious ability in treating or curing various diseases and reducing free radicals. Three popular compounds that could serve as significant sources of natural antioxidants are flavonoids, polyphenols, and saponins (Akbarirad, Ardabili, Kazemeini, & Khaneghah, 2016; Harvard T.H. Chan School of Public Health, 2016). Those antioxidant compounds are particularly found in plant bark (Lukmandaru, Vembrianto, & Gazidy, 2012; Saefudin, Marusin, & Chairul, 2013). Accordingly, testing the content and toxicity of flavonoids, polyphenols and saponins as antioxidant compounds in particular plant species is necessary to look into the efficacy of their portions (e.g. bark, leaves, stems, and twigs) as medicinal plants.

Euphorbiaceae ranks the fourth among the five largest families of woody vascular plants in the Indo-Malesia. Based on research, it was found that there are about 148 species of vascular plants that belong to Euphorbiaceae family, which exhibit potentiality as traditional herbal medicine (Djarwaningsih, 2011). Several studies have reported that particular plant species of Euphorbiaceae were already used as an expectorant, asthma, laxative, kidney ailments, and as a diuretic medicine; and the essential oils extracted from the flowers of *Acalypha hispida* plant (also belonging to this family) were capable of antioxidant actions (Onocha, Oloyede, & Afolabi, 2011).

Pharmacological studies have been conducted on several plant species of Euphorbiaceae; and the results showed their empirical antioxidant effect. Those species included *Acalypha indica*, *Aleurites moluccana*, *Euphorbia antiquorum*, *Phyllanthus niruri* and *Sauropus androgynus*. Further, disclosure of antioxidant potentiality is

associated with bioactive compounds contained in the plant extracts. One of the effective indicators to determine efficacy of antioxidant compounds is by examining its peroxide value (POV), which demonstrates or indicates the compound ability to react with free radicals; and accordingly those compounds are able to inhibit or slow down the oxidation process of special fatty matters (particularly their unsaturated components) in biomass bodies. On the other hand, possible toxicity test that might be inflicted by plant materials that actually exert beneficial antioxidant action is very important to be carefully considered and thoroughly watched as a medicinal herb to secure the living creatures, particularly humans. Toxic effects of plant extracts in vitro cultures can also be used to examine the ability of extract nature to inhibit the proliferation of cancer cells, e.g. Hella cell cancer (Saefudin, Syarif, & Chairul, 2014). This study is aimed to identify the potentiality of antioxidant activity and toxicity of the eleven bark extract types, each obtained from eleven plant species of Euphorbiaceae. Their antioxidant activity was evaluated by the extract's ability to prevent or inhibit lipid peroxidation exerted by hydrogen peroxide (POH), and ability to reduce (scavenge) free radical at 2.2-diphenyl-1-pikrilhidrasil (DPPH). Meanwhile, toxicity testing was intended as safety precaution of the extracts in their use as herbal drugs, which implemented the so-called Brine Shrimp Lethality Test (BSLT) methods.

II. MATERIAL AND METHOD

A. Materials

The materials were bark portions cut from the stem of 11 tree species, approximately at their breast height. Those 11 species originated from West Java, which are comprised of *Acalypha hispida* Blume, *Baccaurea lanceolata* (Miq.) Müll. Arg, *Bischofia javanica* Blum, *Codiaeun variegatum* (L.) A.Juss, *Croton paniculatus* Lam., *Euphorbia antiquorum* L., *Euphorbia hirta* L., *Jatropha podagrica* Hook, *Glochidion arborescens* Blume, *Macaranga tanarius* (L.) Müll.Arg, and *Sapium baccatum* Roxb.

In their original locations, those trees grew as natural forests, with their unknown ages and varying diameters.

The chemicals used included ethanol, acetic acid, chloroform and sodium thiosulfate (Na_2SO_3) 0.1 N, concentrated hydrochloric acid (HCl), sodium chloride (NaCl), dimethyl sulfoxide (DMSO), and potassium iodate (KIO_3). Other chemicals used were distilled water and starch, 1% solution. The materials for extracts toxicity tests were larvae of shrimp (*Artemia salina* Leach). The tools used were: hammermill, rotary evaporator, freeze dryer, erlenmeyer flasks, and vials (sterile container).

B. Methods

1. Extraction

All of those bark samples of the 11 tree species origin were dried, shaped into powder, and filtered to obtain a coarse-sized powder (8-mesh size). Further, a total of 200 grams of powder per bark type (species origin) was weighed and macerated (extracted) with 70% ethanol solvent for 24 hours. Subsequently, the solvent that already contained bark extract was filtered; and then the obtained filtrate was concentrated with a rotary evaporator until the filtrate volume was reduced to 100 ml, and afterwards dried in a freeze dryer to obtain a dry bark extract.

2. Peroxide test of bark extracts and their ability for scavenging DPPH's free radicals

The peroxide value (POV) test referred to Williams as adopted by Saefudin and Basri, (2016). A total of 5 g dry bark extract was prepared, put into the 100 ml erlenmeyer tube (flask) and then it was added by 30 ml of acetic acid-chloroform (3:2). The tube (flask) is still being shaken, 0.5 ml of a saturated solution of KI and 30 ml of distilled water was added, then titrated using 0.1 N $Na_2S_2O_3$, and it was added again 0.5 ml of 1% starch solution (as indicator), which immediately caused the mixed solution to turn blue colored. The titration was continued until the blue color of solution disappeared and became colorless; and the

volume of $Na_2S_2O_3$ titrant was recorded. Likewise, similar procedures were performed on the standard antioxidant agent, i.e. vitamin E (alpha-tocopherols) as a control. Determination of the peroxide value (POV) for both the alleged antioxidants (in bark extracts) and vitamin E used the formula:

POV (mg) = S x N x 1/1000 g sample ....(1)

where, S = volume of sodium thiosulfate (ml) solution added as titrant; N= normality of sodium thiosulfate solution.

The experiment that dealt with peroxide test was arranged in a completely randomized design (CRD) with single factor. The factor (treatment) was the 11 tree species origins of bark extract samples, whereby three replications were used for each species. The response (observed parameter) was the POV values. If there was a difference in POV among those 11 species, then further assessment proceeded with the Duncan's multiple range tests at 5% level.

Further, the ability of the bark extract in reducing (scavenging) free radicals at DPPH in this study was compared with the POV for vitamin E similarly to cope with the DPPH's free radicals. This is because vitamin E has been used as a natural antioxidant and serves as reductor in the oxidation-reduction process; and consequently as scavenger for DPPH's free radicals. Further, vitamin E typifies as fat-soluble antioxidants. Vitamin E in its roles (and possibly other antioxidant agents with almost similar chemical structures) acts as a radical scavenger (including also the DPPH's free radicals) by delivering its hydrogen (H) atoms to such free radicals (Grossi, Di Lecce, Arru, Toschi, & Ricco, 2015; Evans & Lawrenson, 2017). Activities of how high and convincing the potentiality of the bark extracts was as antioxidant to reduce the DPPH's free radical were assessed with the aid of spectrophotometer device at particular wavelengths (520 nm), by calculating the reduction percentage of DPPH (Q) (Molyneux, 2004; Sharma & Bhat, 2009). Value 0 = no DPPH's free radical scavenging,

while the value of 1 (100%) = total or high damping (scavenging) of free radical. Likewise, the reduction percentage of DPPH by the vitamin E was also assessed for comparison (control). The Q formula (including also the Q value for vitamin E) is as follows:

$$Q = 100\ (A_0 - A_1)\ /\ A_0 \dots\dots\dots\dots\dots\dots(2)$$

where: A_0 = Initial absorbance (DPPH solution), at $\pm$ 520 nm wavelength; A_1 = Absorbance of the DPPH solution (at $\pm$ 520 nm as well) after the addition of bark-extract with certain and similar concentrations, among different bark-extract.

3. Phytochemical screening

Phytochemical screening was conducted on bark extracts of the 11 tree species origin to determine qualitatively if particular components possibly contained in the extracts, which were allegedly capable of antioxidant activity (e.g. scavenging the free radicals). Such allegation focused on 3 (three) prevalent bioactive antioxidants, which comprised polyphenols, flavonoids, and saponins. The method used in this screening test referred to Guevera and Recio (1985).

a. Polyphenol

Ten miligram of bark extract of each tree species origin was inserted into a test tube and then dissolved into 10 ml of hot water. While stirring, 5 drops of 10% NaCl was added into the test tube and it was shaken until the solution became homogeneous. The solution was divided by pouring into two other test tubes. The first served as a positive control tube; and to the second tube was added three drops of reagent (10% $FeCl_3$ solution). Bark extract was regarded as positively containing polyphenols as hydrolyzed compounds, if the extract solution in the second tube turned into blue or dark-blue color. Conversely, if the solution in the second tubes changed to turquoise color, this indicated the presence of polyphenols as the condensed compounds.

b. Flavonoids

Ten miligram of bark extract of each species origin was inserted into a test tube and then hexane solvent was added to extract its coloring pigment exhaustively. The pigment-containing hexane solution was then dried to remove (evaporate) residual hexane. Five mililitre of 80% ethanol was further added into the test tube, and vigorously shaken until it became homogenous. The homogenous solution was subsequently divided into two test tubes. Half mililitre of concentrated HCl and 3-4 drops of magnesium metal granules were added into the first tube. If the color of the solution in the first tube changed and became red, it would be positive of flavonoid presence. Further, the second tube was added with 0.5 ml of concentrated HCl, and then heated over the water bath for 15 minutes. After one hour, if the color of the solution in the tube changed to intense red or violet color, it indicates that the extract contained leuco-anthocyanin.

c. Saponins

Ten miligram of the bark extracts of any tree species origin in a test tube was reconstituted (mixed) with 5 ml of 80% ethanol and then it was added with 5 ml of distilled water. The mixture was shaken vigorously and left to stand for 30 minutes until it became foamy. If the foam height exceeded 3 cm from the upper surface boundary, it will indicate that the bark extract contain saponins.

4. Toxicity test

The toxicity test in this matter used the method called the Brine Shrimp Lethality Test (BSLT) (Meyer et al., 1982). Materials for this test were similarly the bark extracts obtained from the assayed extraction when testing the antioxidant activity. In this regard, the obtained bark extracts of any species origin were dissolved in ethanol, and then the resulting ethanol extract solution was made varying with their staged concentrations progressively, i.e. 0 μg/ml (without bark extract, just ethanol solvent as a control), 10 μg/ml, 100 μg/ml, 1000 μg/ml, and 2000 μg/ml, using the solvent of an artificial seawater (3.8 grams of crude salt, which was not iodized, dissolved in 1 liter of distilled water) and DMSO (dimethyl sulfoxide) solution (with concentration of 20 ml per 1 liter

of distilled water). Each dosage (concentration) of the solution that incorporated artificial seawater and DMSO solvents was made in triplicate with 5 ml volume; and then inserted into the 20-ml vial (sterile container) on which had been marked the volume up to 10 ml. Further, 50 mg of *Artenia salina* shrimp cysts was inserted into another container that already contained the artificial seawater. Half of the container was left open for exposure to light illumination. After 3 days, the shrimp cysts inside the container would become adult (mature) larvae and were ready for the test.

In the next step, a total of 10 mature shrimp larvae were taken from their container; and then inserted into the vial already given 10-ml volume mark, which was previously contained bark extract solution in the mixture of artificial seawater and DMSO solvents in various concentration (dosages), i.e. 0–2000 µg/ml. The larvae inside the vial were left for 24 hours. Observation was conducted by counting the number of the dead larvae. The observation results were expressed as the value of LC_{50}, which signified at what figure was the concentration of the bark extract sample solution that caused the death of as much as 50% of shrimp larvae as of their original number (total) after 24 hour incubation period. The LC_{50} values became the parameters whether the alleged active substances (compounds) were regarded as toxic, less toxic, or not toxic. If the LC_{50} value <1000 µg/ml, then the compound (i.e. bark extract solution in ethanol solvent at the interpolated concentration) could be described as toxic. The smaller the LC_{50} value the more toxic would be the compound; and on the contrary for the greater values. In this regard, the convincing LC_{50} value of ethanol extract solution was figured out using the Probit Finney method (McLaughlin, Rogers, & Anderson, 1998).

The experiment associated with the toxicity test, similar to the previous peroxide test, was arranged in CRD with single factor/treatment. The treatment was also for 11 tree species origins of bark extract solution, with three replications per species origin. The response/ observed parameters were the LC_{50} values. Further assessment proceeded with the 5% level Duncan's multiple range test should a difference occur in the LC_{50}'s among those 11 species.

III. RESULTS AND DISCUSSION

A. Potentiality of Antioxidant

Data in Table 1 revealed as many as 11 types (tree species origin) of ethanolic bark extracts as each originated from 11 tree plant species of Euphorbiaceae family, and their varying peroxide values (POV) that ranged about 81.43-191.56 µg/ml. Out of those 11 types, there were 4 types of bark extracts that exhibited POV lower than or somewhat above those of the positive control (vitamin E; 89.45 µg/ml), which comprised, i.e. *A. hispida* (81.43 µg/ml), *B. javanica* (90.56 µg/ml), *G. arborescens* (91.10 µg/ml), and *S. baccatum* (91.35 µg/ml). This indication demonstrated the ability of those four types of ethanolic bark extracts in inhibiting the oxidation process, which were more effective than or almost as an effective as vitamin E. Meanwhile, the remaining 7 types, which consisted of *M. tanarius* (POV 191.56 µg/ml), *E. antiquorum* (POV 183.40 µg/ml), *J. padagrica* (POV 181.80 µg/ml), *C. paniculatus* (POV 125.15 µg/ml), *E. hirta* (POV 105.78 µg/ml), and *C. variegatum* (POV 104.85 µg/ml) also exerted their ability to inhibit the oxidation process but they were not as effective as vitamin E. It is caused by the fact that peroxide values were far greater than of vitamin E.

Ethanol bark extracts which exhibited POV lower than the stipulated criteria (100 µg/ml) exerted high potentiality in decreasing or scavenging free radicals released by 2.2-diphenyl-1-1 picrylhydrazyl (DPPH); and conversely the reverse was true. One particular bark-extract type from its corresponding plant species origin (*A. hispida*) afforded the lowest POV at 81.43 µg/ml (Table 1), and therefore regarded as the most potential for antioxidant. Further, bark extract from *B. javanica* with POV at 90.56 µg/ml was judged as the second most potential for antioxidant (herbal medicine).

Table 1. Peroxide values (POV) of 11 types of ethanol bark extracts originating from 11 plant species of Euphorbiaceae

No.	Species origin (Scientific name)	Species origin (Local name)	POV (μg/ml)
1.	*Acalypha hispida* Blume	Ekor kucing	81.43a
2.	*Baccaurea lanceolata* (Miq.) Müll.Arg	Lempaung	111.04c
3.	*Bischofia javanica* Blume	Gadog	90.56b
4.	*Codiaeun variegatum* (L.) A.Juss.	Puring	104.85bc
5.	*Croton paniculatus* Lam.	Tutup putih	125.15d
6.	*Euphorbia antiquorum* L	Patikan kebo	183.40e
7.	*Euphorbia hirta* L.	Patikan kebo	105.78bc
8.	*Jatropha podagrica* Hook	Jarak	181.80e
9.	*Glochidion arborescens* Blume	Mareme	91.10b
10.	*Macaranga tanarius(L.)* Müll.Arg	Mara	191.56e
11.	*Sapium baccatum* Roxb.	Ludai	91.35b
Positive control		(Vit. E)	89.45b

Remarks: Mean values followed by the same letter in horizontal direction means they are not significantly different, a < b < c < d (based on Duncan's multiple range test, at 5% level)

There are several factors that could cause such different POV values with varying types of bark extracts, among others the presence of double or triple carbon bonds of particular organic compounds (usually lipid/fat matters) inside the extracts; and the extract content of antioxidant agents. The double or triple bonds are chemically unstable and therefore prone to chemical changes due to heat, light, and oxidation actions, forming the so-called unstable peroxide compounds (Grossi et al., 2015). On the other hand, such changes (especially oxidation) could be prevented or hindered due to the presence of presumably antioxidants in the bark extracts themselves, such as polyphenols, flavonoids, and saponines (Adebiyi & Abatan, 2013).

Nowadays, local people in North Sulawesi utilize bark of *B. javanica* species as ingredients for the drug in curing disease, lumbago (low back pain), and energy enhancer. However, the POV values as described above just indicate the potentiality of a particular substance (including in this regards bark extracts) to be used as antioxidant. This is because such POV values only measure the extent to which a substance has undergone the so-called auto-oxidation,

which are merely free-radical reaction involving oxygen that leads to chemical changes on the substance, e.g. decomposition and ageing. (Grossi et al., 2015). Consequently, in order to ascertain the role of the allegedly antioxidant substance, results of POV examination should be continued with the so-called DPPH (2,2-diphenyl-1-picrylhydrazyl) test. The DPPH is typically an organic substance composed of stable free-radical molecules. Accordingly, the DPPH is used most commonly in the laboratory assay test to monitor chemical reactions that involved radicals (Sharma & Bhat, 2009).

Regarding the bark-extract efficacy as free-radical scavenging or reduction, it was indicated by the particular absorbance intensity of those four bark extract types (Table 2). Absorbance measurement of the bark extract samples of 11 species origin (types) was performed after 14-day storage, which used a spectrophotometer device. In using the spectrophotometer, it was repeated in triplicate in order to obtain more appropriate or convincing absorbance values as well as scavenging-ability figures for any of those four bark-extract types. The obtained values of absorbance varied from 3.07 to 4.36 (Table 2). Meanwhile, the absorbance values

Table 2. Absorbance and ability of scavenging (reducing) the DPPH free radical by four types of ethanol bark extracts

Species origin of bark extracts	Absorbance in 1000 ppm	Reduction/ scavenging ability for lowering free radicals, %[**]
Acalypha hispida Blume [*]	3.86	92.03
Bischofia javanica Blume [*]	3.07	90.89
Glochidion arborescens Blume [*]	4.29	92.56
Sapium baccatum Roxb. [*]	4.36	94.25
Positive control (Vit. E)	3.17	93.54
Negative control (aqueous ethanol liquid; no bark extracts)	0.82	

Remarks: [*] at similar initial particular concentrations of bark extracts; [**] high reduction> 50%; fair reduction>20-50%; low reduction <20%

for positive control (vitamin E) and negative control (aqueous liquid, no bark extracts) were consecutively 3.17 and 0.82. These results suggested that those four types of bark extracts provided satisfactory absorbance values, as indication for their efficacious antioxidant (Table 2), which were mostly far above or differed significantly from those of the positive control/vitamin E (3.17) and of the negative control (0.82). Meanwhile, the absorbance value of B. javanica's bark extract (3.07) was slightly below, but it was still regarded as comparable to that of positive control /vitamin E (3.17).

There were three types of bark extracts with high absorbance values i.e. *A. hispida*, *G. arborescens* and *S. baccatum* exceeding that of vitamin E (3.17), while the value of *A. hispida*'s bark was the lowest (3.86) (Table 2). Further, it was revealed that the greater the absorbance value, the greater would be the scavenging ability figures of the alleged anti-oxidant materials, i.e. bark extracts and vitamin E (Table 2). Consequently, results of absorbance and scavenging ability test following the DPPH's assay strongly (Table 2) confirmed the POV's antioxidant potentiality of those four bark extracts (POV values were lower than or close to the vitamin E's POV) (Table 1), whereby the indicated potentiality of *S. baccatum* Roxb's bark extracts was the highest, followed in decreasing order by *G. arborescens* Blume, *A. hispida*

Blume , and *B. javanica* Blume bark extracts, respectively as the lowest (Table 2). However, it strongly suggested that the activity of bioactive components in *S. baccatum* Roxb bark extracts was more complete and its antioxidant activity afforded the highest (94.25%) value, which was above the capability of vitamin E (93.54%) in reducing (scavenging) the DPPH's free radical (Table 2). The potentiality of antioxidant components of *A. hispida* plants besides being found in their bark portion (the second lowest scavenging ability, 92.03%) also existed in their leaves. The vitamin E and the alleged antioxidants in bark extracts that could perform the H-atom delivery to the DPPH molecules lead to the situation that the DPPH's free radicals were as if preyed or scavenged by those antioxidants (Evans & Lawrenson, 2017).

All those four bark extract types (i.e. *A. hispida*, *B. javanica*, *G. arborescens*, and *S. baccatum*) exhibited high antioxidant potentiality, with their peroxide value (POV) <100 µg/ml at the test using 1000-ppm concentration (Table 1). Besides, in reality those extracts entirely afforded high activity in reducing/scavenging the DPPH's free radical, as their scavenging ability was far above 50%, in the range of 90.89 −94.25% (Table 2). Therefore, the activity of those extracts in scavenging the DPPH's free radical was categorized as very good. In this study, ethanol extraction of *G. arborescens*'s bark

reached 92.56% in reducing the DPPH's free radical (Table 2), which was still higher than the methanol extraction performed by Marusin, Saefudin and Chairul (2013) who achieved only 87.06%. Meanwhile, the activity of reducing the DPPH's free radicals by ethanol extract of *B. javanica* (90.89%) and *S. baccatum*'s bark (94.25%) did not differ much from that of *G. arborescens*'s bark (92.56%).

Further, the high absorbance values (or high reduction/scavenging ability for DPPH's free radicals) (Table 2) were not always followed by the low POV values for each of those four bark extract types (Table 1) and the reverse was so as well. This situation could be attributed to different antioxidant agents in any of the bark extract types, either qualitatively or quantitatively, e.g. polyphenols, flavonoids, and saponines (Table 3). Moreover, the POV values as described before related mostly to the extent of auto-oxidation that have occurred to bark extracts' compounds with possible free radical releases (Ali, Wahid, Khatune, & Islam, 2015), while the more confirmed DPPH's assay focused more on the scavenging of DPPH's free radicals by the alleged antioxidant agents in those extracts (polyphenols, flavonoids, and saponines) as well as by vitamin E (Sharma & Bhat, 2009). Despite uncertain relation in results between the POV test and DPPH's free radical assay, it could be asserted convincingly that those four bark extract types with lower POV values (or somewhat higher) than the values for vitamin E (Table 1) could in fact afford the reduction or scavenging of DPPH's free radicals as much as 90.89–92.45%, comparable spectacularly with those of vitamin E as well (Table 2).

Still further, when referred to the results of phytochemical screening test (Table 3), the antioxidant activities exerted by bark extract types of *A. hispida* and *S. baccatum* was regarded as quite strong (Table 2), if compared to the types of *B. javanica* and *G. arborescens*. Bioactive screening results strongly indicated qualitatively that *A. hispida* and *S. baccatum*'s bark extracts contained the most polyphenol compounds

(+++). These results suggested the potentiality of such compounds in the ethanol extract in *A. hispida* and *S. baccatum* barks other than for antioxidant uses, which could be used as herbal medicine. Polyphenols typify as compounds which have the basic structure of phenol units with more than one hydroxyl (OH) groups, whereby the OH groups are attached directly to an aromatic hydrocarbon ring (Dhianawaty & Ruslin, 2015). Polyphenols yielded by particular plant species exerted antioxidant properties and is effective in preventing dangerous diseases such as cancer (Miryanti, Sapei, Budiono, & Indra, 2011), heart attacks, and blood vessel disease (Rodella & Favero, 2013).

When compared to the apparent polyphenol presence (content) in the positive control (vitamin E), the apparent contents in bark extracts from *A. hispida* Blume and *S. baccatum* Roxb. were similar; but still greater than the apparent polyphenol contents in *B. javanica* Blume and *G. arborescens* Blume bark extracts (Table 3). This situation was almost commensurate with the more confirmed DPPH's assay results, whereby the ability of *A. hispida* Blume and *S. baccatum* Roxb bark extracts as the alleged antioxidants to scavenge DPH's free radicals as much as 92.03% and 94.25%, respectively was conveniently comparable to those of vitamin E (93.54%) (Table 3). From these phenomena, it could be judged that the polyphenols in particular types of bark extracts took substantial roles in reducing the DPPH's free radicals.

A. hispida's bark extract was also indicated qualitatively to contain the highest flavonoid (+++) compounds (Table 3). Flavonoids also belong to polyphenols which can inflict positive effects on human health as free-radical scavenger, since they can donate H atoms (reducing agent) to the free radicals thereby stabilizing those radicals, hence not inducing oxidation (Puspitasari, Wulansari, Widyaningsih, Maligan, & Nugrahini, 2016), and removing toxic metals from the human body (Kumar, Mishra, & Pandey, 2013; Kumar & Pandey, 2013). Flavonoid compounds easily

change, due to the influence of oxidation, light, and chemical agents, thereby decreasing the function of its active ingredient and solubility. Stabilizing and improving the solubility of flavonoids can be done by converting them into glycosides form.

When compared to the apparent flavonoid content in the positive control (vitamin E), the apparent contents in *A. hispida* Blume bark extracts were similar; and exhibited the greatest value (Table 3), followed in decreasing order by *S. baccatum* Roxb. and *G. arborescens* Blume bark extracts (both as the second apparent greatest), and ultimately by *B. javanica* Blume bark extracts (as the apparent lowest). This situation, however, was rather inconsistent with the DPPH's assay results, whereby the ability of *S. baccatum* Roxb. bark extract to scavenge DPPH's free radicals was the greatest, while the ability of *A. hispida* Blume bark extracts to do so was the second lowest (Table 2). This occurrence strongly indicates that although it is able to serve as antioxidant, however, the role of flavonoids in bark extracts to scavenge the DPPH's free radicals was not so pronounced compared to the role of polyphenols.

Saponin as bioactive components was also qualitatively present in bark extracts with its content categorized indicatively as low (+) to moderate (++) compared to that with positive control/vitamin E (+++) (Table 3). In this study, saponin was supposedly found only slightly (+) in *A. hispida* bark extract. Saponin belongs to a class of complex natural compounds in the form of glycoside. This

antioxidant can decrease LDL (low-density lipoprotein) cholesterol in the blood, inhibit the growth of colon cancer and is able to neutralize blood sugar by stimulating insulin secretion from the pancreas (Vinarova et al., 2015).

The apparent saponine contents in *B. javanica* Blume, *G. arborescens* Blume, and *S. baccatum* Roxb bark extracts, respectively seemed similar to each other; while the apparent content in *A. hispida* Blume bark extracts was the lowest (Table 3). Further, all the apparent saponine contents in those four bark extract types were lower than the apparent content in the positive control (vitamin E). These phenomena were notably inconsistent with the results of DPPH's assay test (Table 2), whereby the ability of *S. baccatum* Roxb bark extracts as the alleged antioxidant to reduce (scavenge) the DPPH's free radicals exhibited the greatest (94,25%) value, which was even greater than the ability of vitamin E (93.54%). This occurring situation strongly suggests that, almost similar to the case of flavonoid' alleged antioxidant, the role of saponine' antioxidants to scavenge the DPPH's free radicals was less efficacious than the role of polyphenols. Further, judging from all the overall phenomena (Tables 2 and 3), which convincingly indicates that the role of polyphenols as the alleged antioxidant to scavenge the DPPH's free radicals was the strongest (Table 3), compared to the other alleged antioxidants (flavonoids and saponine), with its achievement closer to the role of positive control (vitamin E).

To sum up, those four types of ethanol bark

Table 3. Bioactive compounds indicatively present (identified) and yielded from the screening test on four types of bark extracts with their corresponding species origin

Species origin for bark extracts	Bioactive compounds		
	Polypenol	Flavonoids	Saponin
Acalypha hispida Blume	+++	+++	+
Bischofia javanica Blume	++	+	++
Glochidion arborescens Blume	++	++	++
Sapium baccatum Roxb.	+++	++	++
Positive control (Vit. E)	+++	+++	+++

Remarks: +++ apparently enormous/intensive/strong reaction occurred; ++ apparently fair/moderate reaction; + apparently slight/weak reaction

extracts with species origin (i.e. *A. hispida*, *B. javanica*, *G. arborescens* and *S. baccatum*), following the peroxide test, which exhibited the POV below or almost similar to that of vitamin E (Table 1); and following oxidation-reduction test for the DPPH's free radical scavenging ability, which ranged about 90.89—94.25% (Table 2), after their chemical screening test for bioactive components (Table 3), were in part strengthened regarding their efficacy as the alleged antioxidants.

B. Toxicity Tests and Possible Effects

Results of toxicity test on wood bark extracts of 11 plant species origin (Table 4) revealed the varying activity associated with their LC_{50} values, beginning from being very toxic (LC_{50} 170.86—347.87 µg/ml), moderately toxic (LC_{50} 424.59—659.12 µg/ml), until weakly toxic (LC_{50} 659.78—932.82 µg/ml) (Table 4). In accordance with the criteria stipulated by Meyer et al. (1982), bark extracts originated from 5 species were regarded as toxic, because their LC_{50}'s value < 1000 µg/ml. Bark extracts of three particular plant species origin, which comprised *Euphorbia antiquorum* L (LC_{50} 238.85 µg/ml), *Euphorbia hirta* L (LC_{50} 228.11 µg/ml), and *Jatropha podagrica* Hook (LC50 194.51 µg/ml) belonged to those species which were the most toxic, since they inflicted the most sensitive (deadly/lethal) effect on *A. salina* shrimp larvae. This is because their low LC_{50} values lay in the range regarded as very toxic (LC_{50} 170.86-347.87 µg/ml), as described above; and further resulted in the death of numerous larvaes. Meanwhile, bark extracts from *Bischofia javanica* Blume (LC_{50} 508.31) and *Glochidion arboreum* Blume (LC_{50} 522.38) were regarded as moderately toxic. Ultimately, bark extracts from six other species were judged as not toxic or safe, and therefore could be used as secure or harmless traditional medicine for the community in the village vicinity.

The use of *Jatropha podagrica* Hook (castor oil-bearing) seeds by local community is as traditional medicine particularly to cure ringworm diseases, former injury, and giving birth (baby delivery). The secondary metabolite compounds which are toxic to the living creatures typify as alkaloids that exist in the extracts of the nine species origin for castor-oil bearing seeds (Table 4). Others bioactive compounds, particularly in the extract of Jatropha podagrica bark comprised among others fraxidin, fraxetin, scoparone, 3-acetylaleuritolic acid, β-sitosterol and sitosterone (Rumzhum et al., 2012). Utilization of those compounds in traditional remedies is to cure dysentery, bronchitis, breast inflammation, typhus, kidney and milk gland irritation.

Bark extracts of 9 out of 11 plant species origin were tested for their toxicity (Table 4), were categorized as being poisonous (toxic), due to their LC_{50} values < 1000 µg/ml (Meyer et al., 1982). Accordingly, almost all those extracts could exhibit potentiality as natural herbal drug. Consequently, precautionary measures should be thoroughly taken in their uses, particularly when determining the concentration or dosages of those herbal drugs. Accordingly, bark extracts with high toxicity should be used in low dosages; and conversely for those with low toxicity.

Wood bark extracts originating from B. javanica (LC_{50} 508.31) and *G. arboreum* (LC_{50} 522.38 µg/ml were regarded as fairly or moderately toxic according to the Meyer (1982)'s criteria, because their LC_{50} values were in the range of 424.59-659.12 µg/ml. Meanwhile, bark extracts from *Euphorbia antiquorum* L. (LC_{50} 238.85 µg/ml), *Euphorbia hirta* L. (LC_{50} 228.11 µg/ml), and *Jatropha podagrica* Hook (LC_{50} 194.51 µg/ml) were judged as the most toxic, because they exhibited very strong deadly activities according to those criteria (their LC_{50} values were far below the criteria's LC_{50} values).

With respect to the four particular bark extracts each originated from four tree species, which have been judged as efficacious antioxidant agents (Table 3), *Acalypha hispida* and *S. baccatum* Roxb. bark extracts were regarded as safe or not toxic to living creatures, as already tested against *A. salina* shrimp larvae with their LC_{50} values of 1113.87 µg/ml and 1080.37 µg/

Tabel 4. LC_{50} values for ethanol bark extracts of eleven plant species origin

No.	Species origin	Local name	LC_{50}
1.	*Acalypha hispida* Blume	Ekorkucing	1113.87
2.	*Baccaurea lanceolata* (Miq.) Müll. Arg	Lempaung	902.20
3.	*Bischofia javanica* Blume	Gadog	508.31[++]
4.	*Codiaeun variegatum* (L.) A. Juss.	Puring	804.56
5.	*Croton paniculatus* Lam.	Tutup putih	902.50
6.	*Euphorbia antiquorum* L.	Patikan kebo	238.85 [+++]
7.	*Euphorbia hirta* L.	Patikan kebo	228.11[+++]
8.	*Jatropha podagrica* Hook	Jarak	194.51[+++]
9.	*Glochidion arboreum* Blume	Mareme	522.38[++]
10.	*Macaranga tanarius*(L.) Müll. Arg	Mara	985.46
11.	*Sapium baccatum* Roxb.	Ludai	1080.37

Remarks: +++ Enormously/extraordinarily toxic); ++ Fairly/moderately toxic; +++ Highly/very toxic; LC_{50} = lethal concentration of the alleged toxic substance (i.e. bark extracts in this regards) that could kill as many 50% of the individual organisms of their original number

ml, respectively (both > 1000 µg/ml) (Table 4); and therefore the bark extracts from those two species origin could be regarded as harmless in their use for antioxidants (A.O.T., Orekova, & Yakubu, 2012; Adebiyi & Abatan, 2013). Meanwhile, *B. javanica* Blume and *G. arborescens* Blume bark extracts, judged also as efficacious antioxidants (Table 3), were considered as moderately toxic (LC_{50} values 508.31 µg/ml and 522.31 µg/ml, both still in the range of 424.59-659.12 µg/ml). Accordingly, special precautionary measures on those two bark types should be thoroughly taken for their uses as antioxidants.

Scrutinizing Table 3, *A. hispida* Blume and *S. baccatum* Roxb. bark extracts apparently exhibited greater presence (content) of polyphenol as well as flavonoid compounds than *B. javanica* Blume and *G. arborescens* Blume bark etracts. Meanwhile, saponine presence/contents in *B. javanica* Blume, *G. arborescens* Blume, and *S. baccatum* Roxb. bark extracts, respectively seemed to be similar to each other; and the saponine content in *A. hispida* Blume bark extract was apparently the lowest. However, judging from the toxicity test results (Table 4), it turned out that *A. hispida* Blume and *S. baccatum* Roxb. bark extracts were regarded as harmless or non-toxic, because their LC_{50} values (1113.87

and 1080.37 µg/ml, respectively) were greater than 1000 µg/ml; while *B. javanica* Blume and *G. arborescens* Blume bark extracts afforded moderate toxicity with their LC values (508.31 and 522.38 µg/ml, respectively) lower than 1000 µg/ml. These phenomena accordingly led to the strong indication that the varying (different) toxicity behaviors (actions) among those four types of bark extracts, as tested against *A. salina* shrimp larvae, were not related with their presence (content) of those three alleged antioxidants (i.e. polyphenols, flavonoids, and saponine). Instead, such toxicity difference could be due to the varying contents/presence of presumably specific toxic ethanol-soluble compounds (other than those three alleged antioxidants) in the extracts, such as quercetin, taxifolin, lignans, stilbenes, glycosides, alkaloids, and phlobaphenes (Sjostrom, 2013; Mota et al., 2017).

The death of *A. salina* shrimp larvae inflicted by particular bark extracts became a beneficial parameter to indicate their content of active compounds which were toxic. The toxicity rate of a compound could be assessed from its LC_{50} value, using the so-called probit-log concentration graph. If the LC_{50} values < 1000 µg/ml, then their corresponding compounds were judged as toxic. In other words, the

smaller the LC_{50} values, the more toxic would be the compounds. Accordingly, bark extracts originating from *A. hispida* and *S. baccatum* species with their LC_{50} values greater than 1000 μg/ml were regarded as safe or not toxic to be used as herbal drugs (Table 4). Meanwhile, bark extracts from other species such as *Baccaurea lanceolata* (Miq.) Müll. Arg, *Codiaeun variegatum* (L.) A. Juss., *Codiaeun variegatum* (L.) A. Juss, *Croton paniculatus* Lam, *Macaranga tanarius* (L.) Müll. Arg and *Sapium baccatum* Roxb still could be used safely as traditional medicines, particularly for curing ringworm diseases, former injury, and baby delivery, although they were regarded as less effective. That was based on the content of polyphenols, flavonoids, and saponins in the bark extracts as examined in this research. Therefore, the belief adopted by the community as the herbal remedy was made possible due to the activity of other chemical contents than those three compounds. Based on field observation, the utilization of bark portion from those plant species by the community around the forests in Banten, Lampung, and Bengkulu was caused by their ease to obtain. In addition, those plant species were also growing in the vicinity of their house as ornament or decorative plants.

IV. CONCLUSION

Wood bark extracts originating from four out of eleven plant species that belonged to Euphorbiaceae family, i.e. *Acalypha hispida* Blume, *Bischofia javanica* Blume, *Glochidion arboreum* Blume, and *Sapium baccatum* Roxb., exhibited their potentiality as antioxidant sources. Results, phytochemical screening strongly suggested that there was a strong association between high free radical scavenging and amount of antioxidant compounds, particularly polyphenols in wood bark.

Toxity test revealed that bark extracts from *B. javanica* (LC_{50} 508.31) and *G. arboreum* (LC_{50} 522.38) species were able to inflict fair or moderate toxic effect. Meanwhile, bark extracts from *Euphorbia antiquorum* L. (LC_{50} 238.85 μg/

ml), *Euphorbia hirta* L. (LC_{50} 228.11 μg/ml), and *Jatropha podagrica* Hook (LC_{50} 194.51 μg/ml) could deliver the most toxic effect or afford very strong toxicity actions.

Utilization of bark extracts from six other plant species origins, i.e. *Baccaurea lanceolata* (Miq.) Müll. Arg, *Codiaeun variegatum* (L.) A. Juss., *Codiaeun variegatum* (L.) A. Juss, *Croton paniculatus* Lam, *Macaranga tanarius* (L.) Müll. Arg, and *Sapium baccatum* Roxb., was for traditional medicines to cure dysentery, bronchitis, breast irritation, kidney troubles, and milk gland inflammation. However, their use as herbal drugs was less effective, viewed from their content of polyphenols, flavonoids, and saponins. Accordingly, community belief in bark uses as the herbal remedy became possible due to the activity of other chemical contents than those three compounds.

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ANATOMICAL PROPERTIES OF NINE INDIGENOUS RATTAN SPECIES OF JAMBI, INDONESIA

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ANATOMICAL PROPERTIES OF NINE INDIGENOUS RATTAN SPECIES OF JAMBI, INDONESIA. Various rattan species grow naturally in Jambi, Indonesia, i.e. opon (*Plectocomiopsis geminiflora* (Griff.) Beccari), udang (*Korthalsia flagelaris* Miquel), getah (*Daemonorops micracantha* (Griff.) Beccari), duduk (*D. didymophylla* Beccari), tunggal (*Calamus laevigatus* Martius), sijau (*C. tumidus* Furtado), buruk ati (*C. insignis* Griff. var. *longispinosus* Dransfield), batu (*C. zonatus* Beccari), and paku (*C. exillis* Griff.). The rattan species are classified as lesser known species, which its properties are unknown to rattan supplier and consumers. This paper observes the anatomical properties of nine indigeneous rattan species of Jambi. Anatomical observations were conducted from solid, sectioned and macerated samples. Results show that anatomical properties become a diagnostic characteristic for rattan species identification and specific characteristic has been developed for key species determination. Vascular bundles in the outer part of the stem of opon and udang rattans are yellow-capped. Width and length ratio of vascular bundle in the outer part is more than 1, oval shape was found in sijau rattan, while elongated shape vascular bundle with the ratio less than 1 was found in buruk ati. Fiber bundles separated from vessels are found in central ground parencymatous tissue of rattan tunggal. In the peripheral area, fiber bundle forms one or two lines with no specific pattern found in rattan paku, while fiber bundles in one line with alternate pattern found in rattan duduk. Single resin canals are found both in center part and peripheral area is found in batu rattan and mostly single. Resin canals are found in pair at rattan getah stem. Tentative identification key to rattan species has been developed for nine species investigated, then the key should be developed for further genera identification among rattan species in Indonesia.

Keywords: Anatomical properties, nine indigenous rattan species, Jambi, identification key

*SIFAT ANATOMI SEMBILAN JENIS ROTAN ASLI JAMBI, INDONESIA. Beberapa jenis rotan tumbuh secara alami di wilayah Jambi, Indonesia, yaitu opon (*Plectocomiopsis geminiflora (Griff.) Beccari), udang (Korthalsia flagelaris Miquel), getah (Daemonorops micracantha (Griff.) Beccari), duduk (D. didymophylla Beccari), tunggal (Calamus laevigatus Martius), sijau (C. tumidus Furtado), buruk ati (C. insignis Griff. var. longispinosus Dransfield), batu (C. zonatus Beccari), dan paku (C. exillis Griff.). Rotan tersebut termasuk rotan yang kurang dikenal, karena sifat dan karakteristiknya belum diketahui oleh konsumen dan penyuplai rotan. Tulisan ini mempelajari sifat anatomi sembilan jenis rotan yang tumbuh secara alami di Jambi. Observasi karakteristik anatomi batang rotan dilakukan dari contoh utuh, preparat sayatan, dan preparat maserasi. Hasil penelitian menunjukkan bahwa sifat dan karakteristik anatomi batang rotan dapat dijadikan karakteristik diagnostik untuk identifikasi jenis rotan. Berkas pembuluh pada bagian luar rotan opon dan udang memiliki lapisan berwarna kuning pada ujungnya (yellow capped). Perbandingan lebar dan tinggi berkas pembuluh bagian luar lebih dari satu, bentuk oval dijumpai pada rotan sijau, sementara bentuk lonjong memanjang dengan rasio lebar dan panjang kurang dari satu dijumpai pada rotan buruk ati. Berkas serat yang terpisah dari berkas pembuluh di bagian tengah dari parenkima dasar dijumpai pada rotan tunggal. Pada bagian luar batag, berkas serat membentuk satu atau dua garis dengan pola tidak beraturan terlihat pada rotan paku, sementara berkas serat dengan pola membentuk satu garis tampak pada rotan duduk. Saluran getah di bagian tengah dan luar bertipe tunggal dijumpai pada rotan batu, sedangkan pada rotan getah saluran getah berpasangan. Sifat anatomi batang rotan selanjutnya disusun dalam bentuk kunci determinasi untuk identifikasi jenis rotan. Untuk sembilan jenis rotan dari Jambi, kunci determinasi telah dikembangkan dan disarankan untuk dikembangkan untuk identifikasi genus untuk seluruh jenis rotan yang tumbuh di Indonesia.*

Kata kunci: Sifat anatomi, sembilan jenis rotan asli, Jambi, kunci identifikasi

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I. INTRODUCTION

Rattan is a group of spiny and climbing palms which is classified into Monocotyledons, Palmae family. Botanically, it is about 600 rattan species grouped into 13 genera grows around the world (Zehui, 2007). Among 13 genera, there are only four generas are traded commercially, i.e. Calamus, Daemonorops, Korthalsia, and Plectocomia. From 600 rattan species, it was recorded about 312 rattan species grown in Indonesian forest and 51 species of them has been traded commercially (Sumarna, 1996 in Rachman & Jasni, 2013).

Currently, rattan resources are available to support Indonesian rattan industry. Although rattans are recognized and utilized for centuries, rattan resources were not depleting until the 1970s when the demand for rattan cane was increasing rapidly (Zehui, 2007). Since 2012, Indonesian rattan export has been banned through the Indonesian Ministry of Trade Regulation No.35, 36, 37/2011. The export ban is aiming to support local industries, however the ban policy has been impeding the livelihood of rattan farmers and interpreneurs (Otniel, 2013). One possible reason, the current traded rattan species is exclusively for those of commercial rattan species but the lesser known rattan species.

Referring to lesser known timber species defined by (Sosef, Hong, & Prawirohatmodjo, 1998), lesser known rattan species is defined as those rattan species which are little known or known only locally and are not marketed or are marketed on small scale only. Lesser known rattan species fall into one of the lesser known criteria that rattan species existence and its properties are largely unknown to rattan supplier and consumers. The species is ignored because more commercial rattan species predominate the forest and better known. Lesser known rattan species could be assumed that public is unfamiliar with these species, then the need for more research. The term lesser known species is similar with those of less used species which suggests a lack of market acceptance and utilization (Sosef et al., 1998).

Prior to rattan utilization, species identification is one important process to determine its use. In general, rattan species is accurately identified based on its taxonomic characteristics such as habitus, leafs, climbing organ, infloresecens and flower type (Abasolo, 2015). However, once rattan stems are cut and leaf sheaths removed, species identification becomes difficult (Ebanyenle & Oteng-Amoako, 2003).

Currently, rattan collectors harvest rattan stem based on the local name and stem diameter irrespective its botanical name. The local names often vary from one locality to another and sometimes the same name is given to more than one species. Jambi is an area where rattan grows naturally. There is various rattan species grows in Jambi's forest and has not been commercially utilized. Rattan species identification would support rattan genetic conservation and led to efficient rattan utilization. Weiner and Liese (1990) and (Astuti (1990) stated that the anatomical properties of rattan stem cross section could become a diagnostic characteristic for rattan species identification. This paper studies the anatomical propertis of nine rattan species grown in Jambi's forest. The anatomical data is described for rattan species identification purposes.

II. MATERIAL AND METHOD

Nine rattan species are collected from Marangin-Bangko forest, Jambi Province, where nine indigenous rattan species grows naturally in the area. Nine matured stems were collected randomly from different growing clumps for each species. Herbarium samples were collected for species identification purposes in the Botany Research Group, Forest Research and Development Center (P3H), while rattan stem were collected for macroscopic, microscopic, and fiber dimension assessments. Macroscopically, solid rattan stem was cut using sharp knife and was observed under stereo-microscope. Microscopically, cross-sectional rattan stems were sliced into 35 – 45 µm using a microtome. These sectioned were then red-
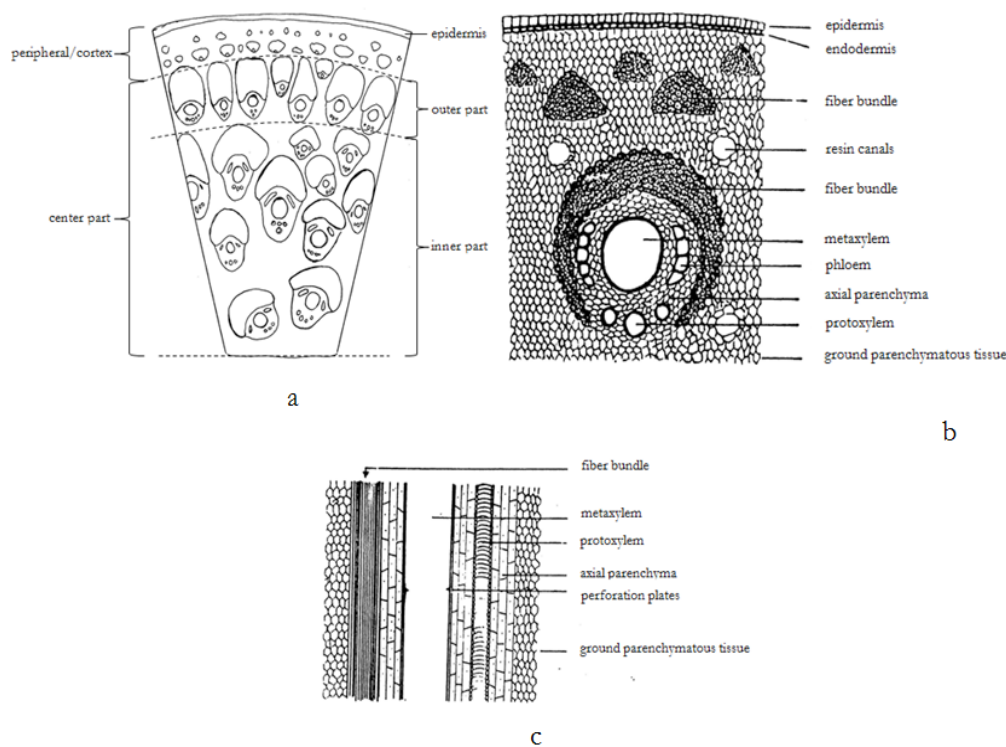
Figure 1. General structure and observation area (a), transversal section (b), lateral section (c)

Source: Astuti (1990); Krisdianto and Jasni (2005); Mandang and Rulliaty (2004)

stained using safranin, dehydrated in ethanol sequence (35–100%) prior to mount it in object glass with entellan. (Sass, 1961 as cited by Rulliaty, 2014). Two milimetre by two milimetre transversal stem in two centimetres length stem was macerated according to modified Forest Products Laboratory method as mentioned by Rulliaty (2014).

Rattan stem observation area is modified based on Astuti (1990), Krisdianto and Jasni (2005), and Jasni, Krisdianto, Kalima, and Abdurachman, (2012). Rattan stem anatomical properties is observed based on Mandang and Rulliaty (2004), Weiner and Liese (1990) and Krisdianto and Jasni (2005). The schematic observation is shown in Figure 1a, and anatomical rattan stem properties is shown in Figure 1b and 1c.

III. RESULT AND DISCUSSION

Anatomical properties of nine rattan species are described as follows:

A. Batu (*Calamus zonatus* Beccari)

Single layer epidermis consisting of unlignified parenchyma cells and covered by siliceous layer interspersed with few stomata cells. The epidermis layer is about 19.01 ± 1.92 μm and the endodermis layer is about 4.6 ± 0.75 μm. In the peripheral area, fiber bundles are arranged in one to two layers with resin canals found in the peripheral area (Figure 2b). The peripheral area is about 136.81 ± 9.26 μm from the outer bark. Vascular bundle in the outer part is about 12–13 per mm², with the width and length (W/L) ratio is 0.9 ± 0.3, which means vascular bundle's width is approximately similar with vascular bundle's length. Yellow cap is absent, and metaxyem vessel diameter is 99.27 ± 27.22 μm.

As commonly found in monocotyledonous stem structure, vascular bundle in the inner part is greater in diameter than those of the outer part. The elipse to oblique vascular bundle length and width is 448.4 ± 53.6 μm and 359.75

± 43.04 µm, respectively. The vascular bundle in the inner part is 6–8 per mm², with the width and length (W/L) ratio is 0.81 ± 0.08. Metaxylem vessels are mostly single, sometime found in pair, with diameter of 211.35 ± 26.65 µm. Protoxylem consists of a cluster 2–6 cells, with single cell diameter of 40.61 ± 10.65 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 2c). Individual phloem cell diameter is about 27.89 ± 6.17 µm. Resin canals are diffusely distributed in the inner, outer and peripheral areas. Resin canal diameter is 68.81 ± 10.23 µm.

Fiber sheath is extensively broader in vascular bundle of peripheral area and normal 'horse-shoe shaped' in vascular bundle of inner part. Fiber length is 1,821.16 ± 169 µm, width

20.4 ± 3.21 µm, lumen 11.76 ± 2.57 µm and wall thickness 4.31 ± 0.71 µm. Ground parenchyma round to oval with varying sizes, type A.

B. Buruk ati (*Calamus insignis* Griff. var. *longispinosu*s Dransfield)

Epidermis is a single layer of unlignified parenchyma cells covered by siliceous interspersed with stomata cells. The epidermis layer is about 32.9 ± 3.78 µm and the endodermis layer is about 10.23 ± 2.23 µm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 3b). The peripheral area is about 352.48 ± 61.66 µm from the outer bark. Vascular bundle in the outer part is about 7–8 per mm2, with the width and length (W/L) ratio is 0.9 ± 0.2, which means vascular bundle's width is approximately
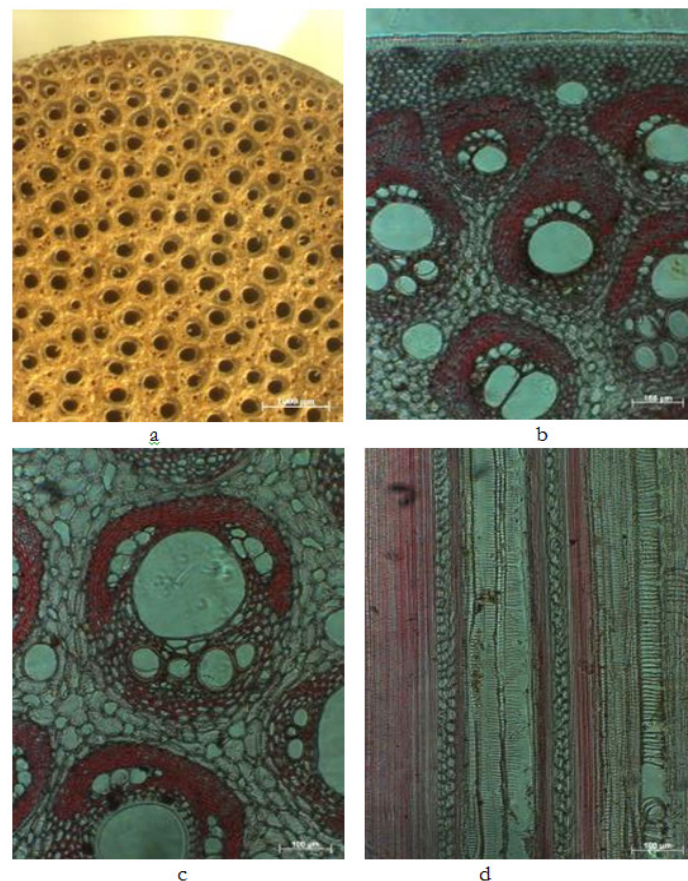

Figure 2. Anatomical structure of batu rattan stem (*Calamus zonatus* Beccari)

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm
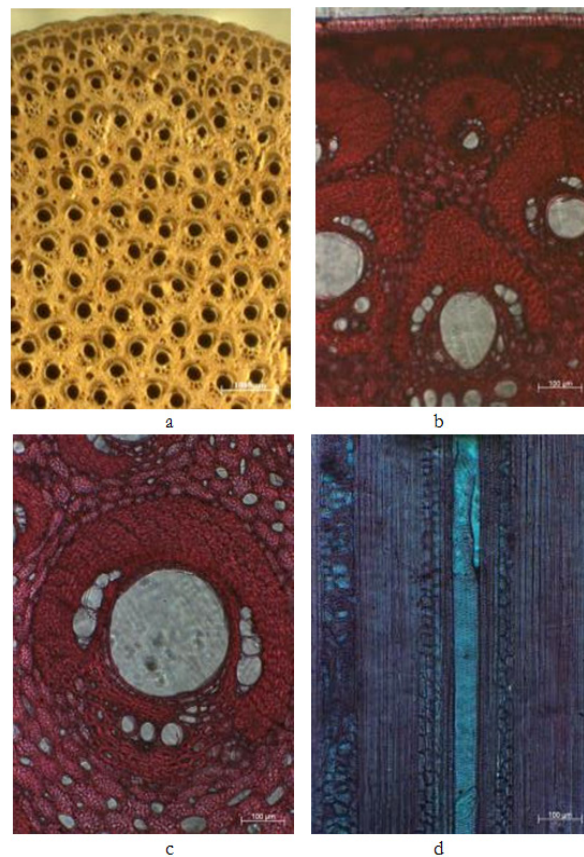
Figure 3. Anatomical structure of buruk ati rattan stem (*Calamus insignis* Griff. var. *longispinosus* Dransfield)

Remarks: a. Stem cross section, scale 1000 μm; b. Stem cross section, scale 100 μm; c. Single vascular bundle, scale 100 μm; d. Lateral section, scale 100 μm

similar with vascular bundle's length. Yellow cap is absent, and metaxyem vessel diameter is 107.42 ± 31.83 μm.

Similar with those of monocotyledonous stem structure, vascular bundle in the inner part is greater in diameter than those of the outer part. The round to oblique vascular bundle length and width is 338.35 ± 68.49 μm and 296.59 ± 52.32 μm, respectively. The vascular bundle in the inner part is only 2–4 per mm², with the width and length (W/L) ratio is 1.05 ± 0.14. Metaxylem vessels are single, with diameter of 295.1 ± 8.47 μm. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of 37.9 ± 8.04 μm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 3c). Individual

phloem cell diameter is about 46.83 ± 8.73 μm. Resin canals are not found, intercellular spaces found in ground parenchyma tissue.

Fiber sheath is extensively longer in vascular bundle of peripheral area and normal 'horse-shoe shaped' in vascular bundle of inner part. Fiber length is 2,381.07 ± 246.98 μm, width 22 ± 2.52 μm, lumen 12.09 ± 2.73 μm and wall thickness 4.95 ± 0.66 μm. Ground parenchyma cells are round to oval with varying sizes, type A.

C. Duduk (*Daemonorops didymophylla* Beccari)

A single layer of unlignified parenchyma cells of epidermis layer covered by siliceous interspersed with few stomata cells. The
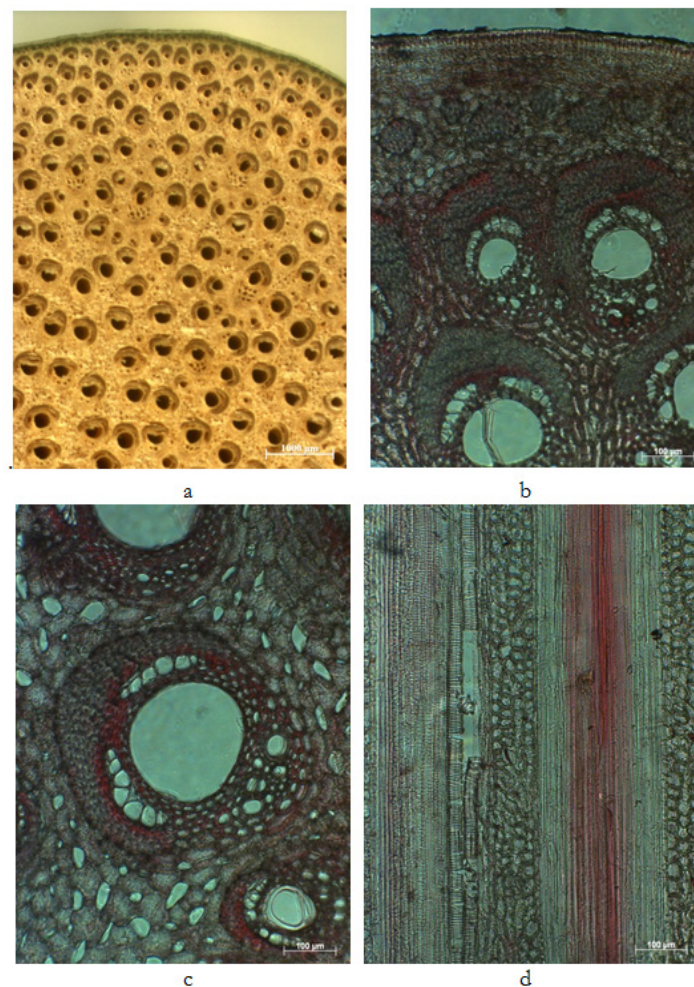
Figure 4. Anatomical structure of duduk rattan stem (*Daemonorops didymophylla* Beccari)

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm

epidermis layer is about 30.67 ± 2.77 µm and the endodermis layer is about 6.83 ± 1.59 µm. In the peripheral area, fiber bundles are arranged in one layer in alternate pattern, smaller and greater fiber bundles one after another (Figure 4b). The peripheral area is about 237.93 ± 18.62 µm from the outer bark. Vascular bundle in the outer part is about 9–11 per mm², with the width and length (W/L) ratio is 0.72 ± 0.09, which means vascular bundle is approximately oval. Yellow cap is absent, and metaxyem vessel diameter is 104.76 ± 28.5 µm.

Vascular bundle in the inner part is greater in diameter than those of the outer part as commonly found in monocotyledonous stem. The oblique vascular bundle length is 451.18 ± 24.15 µm and width is 339.09 ± 57.24 µm. The vascular bundle in the inner part is 4–6 per mm², with the width and length (W/L) ratio is 0.75 ± 0.11. Metaxylem vessels are single, with diameter of 176.16 ± 25.62 µm. Protoxylem consists of a cluster 2–5 cells, with single cell diameter of 26.51 ± 3.66 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 4c). Individual phloem cell diameter is about 26.61 ± 3.5 µm. Resin canal diameter is 36.19 ± 10.01 µm.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and some tapering in the outer part. Fiber length is 1,790.55 ± 228.42 µm, width 20.8 ± 1.17 µm,

lumen 13.15 ± 0.99 μm and wall thickness 3.82 ± 0.37 μm. Ground parenchyma cells are round to oval with varying sizes, type B.

D. Getah (*Daemonorops micracantha* (Griff.) Beccari)

Single layer epidermis consisting of unlignified parenchyma cells and covered by siliceous layer. The epidermis layer is about 29.93 ± 3.11 μm and the endodermis layer is about 12.84 ± 3.38 μm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 5b). The peripheral area is about 208.74 ± 24.27 μm from the outer bark. Vascular bundle in the outer part is about 8–11 per mm², with the width and length (W/L) ratio

is 0.73 ± 0.11, which means vascular bundle is approximately oval. Yellow cap is absent, and metaxyem vessel diameter is 66.32 ± 12.26 μm.

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The oval vascular bundle length and width is 533.25 ± 31.18 and 438.46 ± 74.25 μm, respectively. The vascular bundle in the inner part is 4–6 per mm², with the width and length (W/L) ratio is 0.83 ± 0.18. Metaxylem vessels are single, with diameter of 250.88 ± 13.05 μm. Protoxylem consists of a cluster 4–6 cells, with single cell diameter of 57.78 ± 9.42 μm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells
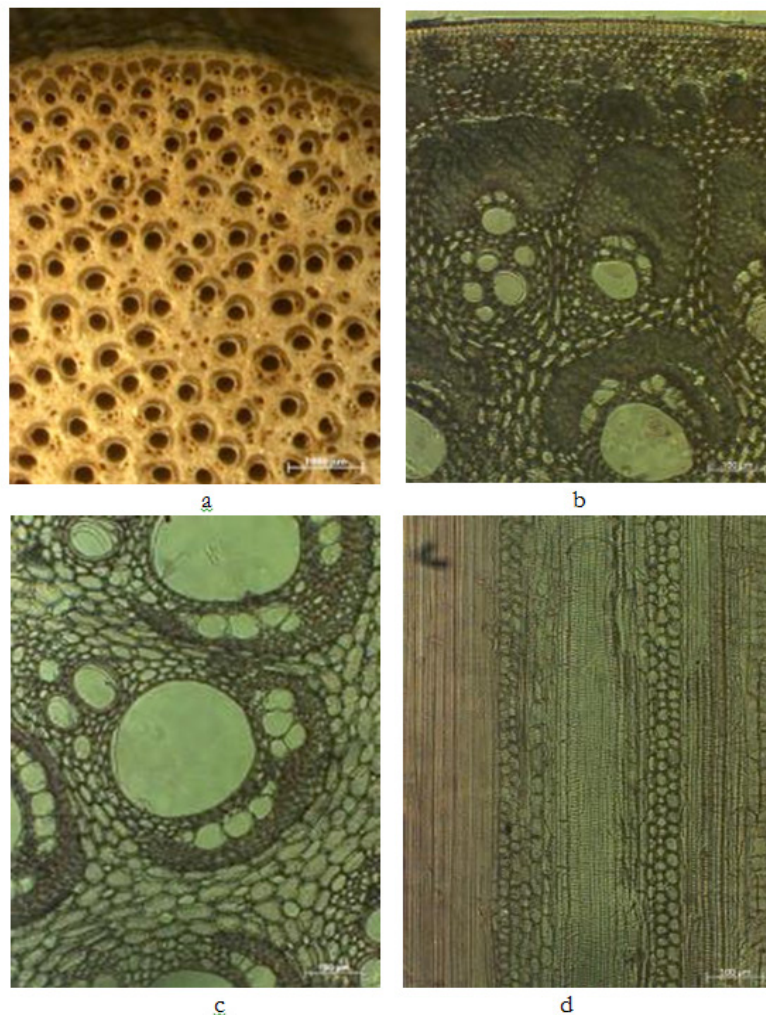

Figure 5. Anatomical structure of getah rattan stem (*Daemonorops micracantha* (Griff.) Beccari)

Remarks: a. Stem cross section, scale 1000 μm; b. Stem cross section, scale 100 μm; c. Single vascular bundle, scale 100 μm; d. Lateral section, scale 100 μm

(Figure 5c). Individual phloem cell diameter is about 50.31 ± 9.07 µm. Resin canal diameter is 100.23 ± 22.71 µm.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and tapering in the outer part. Fiber length is 2,254.43 ± 292.55 µm, width 20.3 ± 2.54 µm, lumen 13.15 ± 2.74 µm and wall thickness 3.41 ± 0.47 µm. Ground parenchyma cells are round to oval with varying sizes, type B.

E. Opon (*Plectocomiopsis geminiflora* (Griff.) Beccari)

Epidermis is a single layer of unlignified parenchyma cells covered by siliceous interspersed with few stomata cells. The epidermis layer is about 30.93 ± 6.24 µm and the endodermis layer is about 4.81 ± 0.96 µm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 6b). The peripheral area is about 145.67 ± 18.4 µm from the outer bark. Vascular bundle in the outer part is about 7–9 per mm², with the width and length (W/L) ratio is 0.98 ± 0.39, which means vascular bundle is approximately round. Yellow cap is found on the top of outer fiber bundle. Metaxyem vessel diameter is 192.59 ± 77.84 µm.

Vascular bundle in the outer part is extensively longer and narrower in the outer part than those in the inner part. In the inner part, vascular bundle is 479.49 ± 87.28 µm length
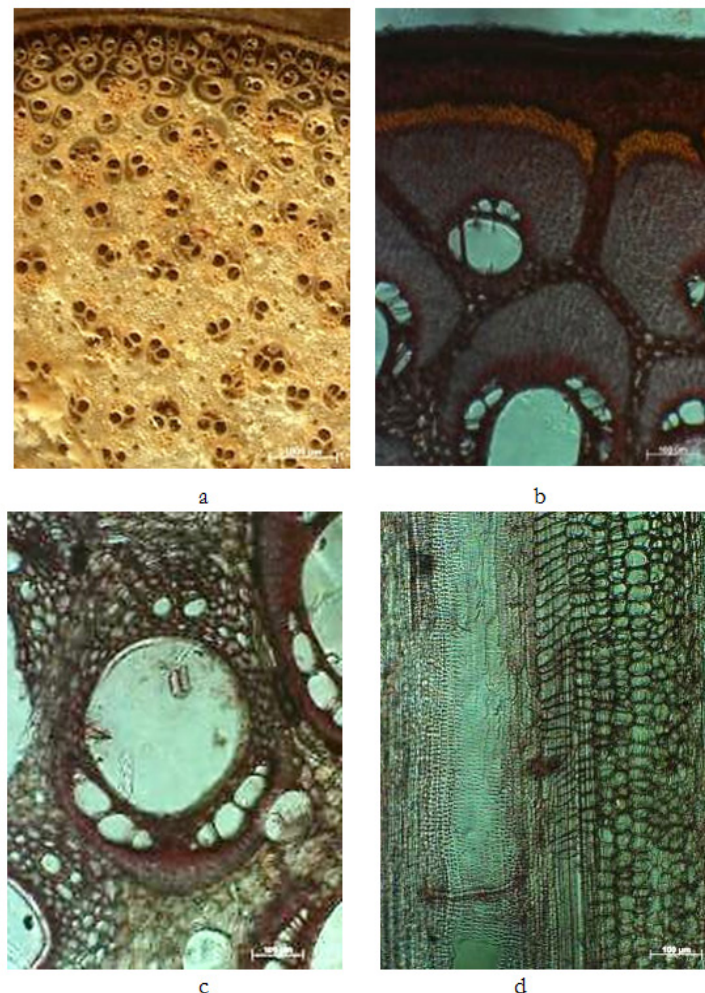

Figure 6. Anatomical structure of opon rattan stem (*Plectocomiopsis geminiflora* (Griff.) Beccari)

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm

and 438.46 ± 74.25 µm width. The vascular bundle in the inner part is 6–8 per mm², with the width and length (W/L) ratio is 0.88 ± 0.16. Metaxylem vessels are mostly single in the outer part, while pair metaxylem vessels are found in the inner part with diameter of 313.2 ± 18.13 µm. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of 35.81 ± 11.97 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 3–6 cells (Figure 6c). Individual phloem cell diameter is about 43.43 ± 6.9 µm. Resin canal diameter is 86.8 ± 20.4 µm.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and tapering in the outer part. Fiber length is 3,518.51 ± 474.51 µm, width 18.1 ± 2.9 µm, lumen 12 ± 2.19 µm and wall thickness 3.05 ± 0.69 µm. Ground parenchyma cells are round to oval with varying sizes, type B.

F.   Paku (*Calamus exillis* Griff.)

Single layer epidermis consisting of unlignified parenchyma cells and covered by siliceous layer interspersed with few stomata cells. The epidermis layer is about 33.84 ± 2.27 µm and the endodermis layer is about 9.82 ± 0.97 µm. In the peripheral area, fiber bundles are arranged in one to two layers with no specific pattern (Figure 7b). The peripheral area is about 173.07 ± 15.46 µm from the outer bark. Vascular bundle in the outer part is about 14–15 per mm², with the width and length (W/L) ratio is 1.05 ± 0.24, which means vascular bundle is approximately round with length and width ratio is about 1. Yellow cap is absent. Metaxyem vessel diameter is 48.69 ± 13.2 µm.

Vascular bundle's shape in the outer part is approximately similar with those in the inner part. In the inner part, vascular bundle is 393.36 ± 35.71 µm length and 336.01 ± 49.33 µm width. The vascular bundle in the inner part is 7–11 per mm², with the width and length (W/L) ratio is 0.86 ± 0.12. Metaxylem vessels are mostly single in the inner part, while pair metaxylem vessels sometime are found in the inner part. Vessel's diameter is 167.31 ± 14.44

µm. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of 33.54 ± 5.94 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4 – 6 cells (Figure 7c). Individual phloem cell diameter is about 26.22 ± 4.7 µm. Resin canal diameter is 34.51 ± 8.14 µm.

Fiber sheath is in 'horse-shoe shaped' and elongated both in inner and outer parts. Fiber length is 1,367.21 ± 199.23 µm, width 19.8 ± 2.48 µm, lumen 13.03 ± 2.08 µm and wall thickness 3.39 ± 0.64 µm. Ground parenchyma round to oval with varying sizes, type B.

G. Sijau (*Calamus exillis* Griff.)

A single layer of unlignified parenchyma cells of epidermis layer covered by siliceous interspersed with few stomata cells. The epidermis layer is about 55.35 ± 1.33 µm and the endodermis layer is about 10.67 ± 0.8 µm. In the peripheral area, fiber bundles are arranged in one layer pattern (Figure 8b). The peripheral area is about 259.48 ± 51.42 µm from the outer bark. Vascular bundle in the outer part is about 4–5 per mm², with the width and length (W/L) ratio is 1.2 ± 0.38, which means vascular bundle is oblique widely. Yellow cap is absent, and metaxyem vessel diameter is 138.9 ± 38.13 µm.

Vascular bundle in the inner part is greater in diameter than those of the outer part as commonly found in monocotyledonous stem. In the inner part, the vascular bundle length is 590.82 ± 66.57 µm and width is 518.52 ± 56.19 µm. The vascular bundle in the inner part is 3–4 per mm², with the width and length (W/L) ratio is 0.88 ± 0.11. Metaxylem vessels are single, with diameter of 255.54 ± 49.19 µm. Protoxylem consists of a cluster 2–4 cells, with single cell diameter of 40.88 ± 14.5 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains 4–6 cells (Figure 8c). Individual phloem cell diameter is about 41.88 ± 6.82 µm. Resin canal is distributed evenly in the ground parenchymatous tissue togteher with intercellular spaces.

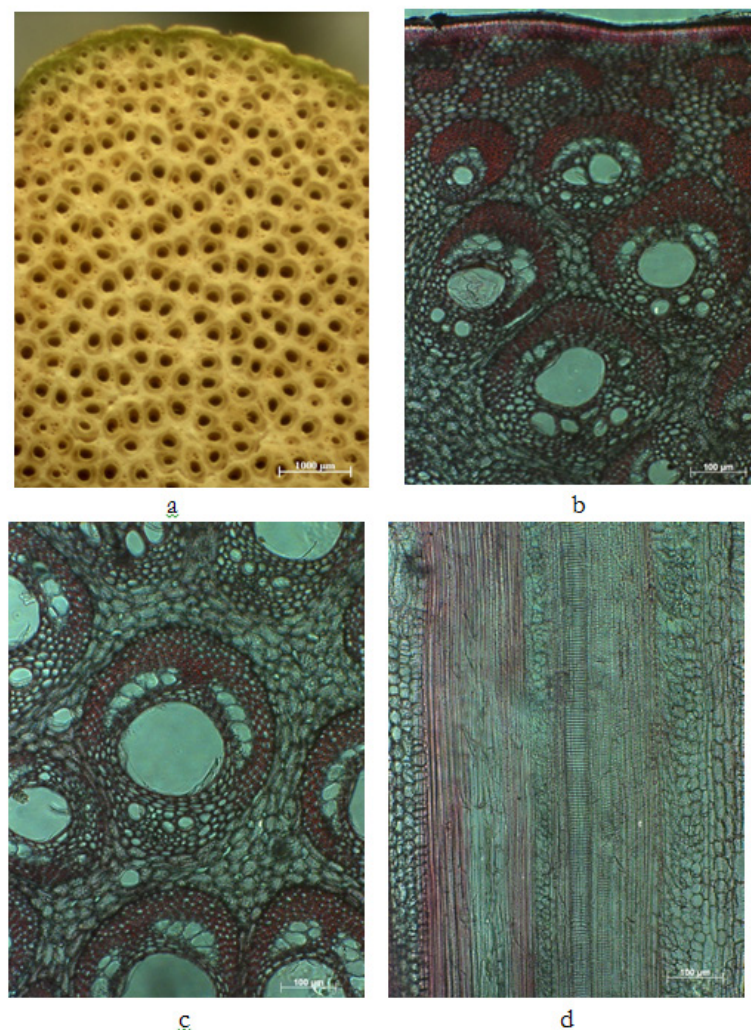Fiber sheath is mostly elongated in outer part and normal 'horse-shoe shaped' in inner

Figure 7. Anatomical structure of paku rattan stem (*Calamus exillis* Griff.).

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm

part's vascular bundle. Fiber length is 1,958.94 ± 177.12 µm, width 21.9 ± 3.39 µm, lumen 12.92 ± 2.75 µm and wall thickness 4.49 ± 0.74 µm. Ground parenchyma cells are round to oval with varying sizes, type B.

H. Tunggal (*Calamus laevigatus* Martius)

Single layer epidermis consisting of unlignified parenchyma cells and covered by siliceous layer. The epidermis layer is about 36.89 ± 4.06 µm and the endodermis layer is about 6.42 ± 1.1 µm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern (Figure 9b). The peripheral area is about 117.94 ± 13.3 µm from the outer bark.

Vascular bundle in the outer part is about 4–5 per mm², with the width and length (W/L) ratio is 0.95 ± 0.17, which means vascular bundle is approximately round. Yellow cap is absent, and metaxyem vessel diameter is 114.49 ± 30.84 µm.

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The round vascular bundle length and width is 443.7 ± 27.06 and 436.3 ± 29.32 µm, respectively. The vascular bundle in the inner part is 4–5 per mm², with the width and length (W/L) ratio is 0.99 ± 0.09. Metaxylem vessels are single, with diameter of 226.76 ± 28.46 µm. Protoxylem
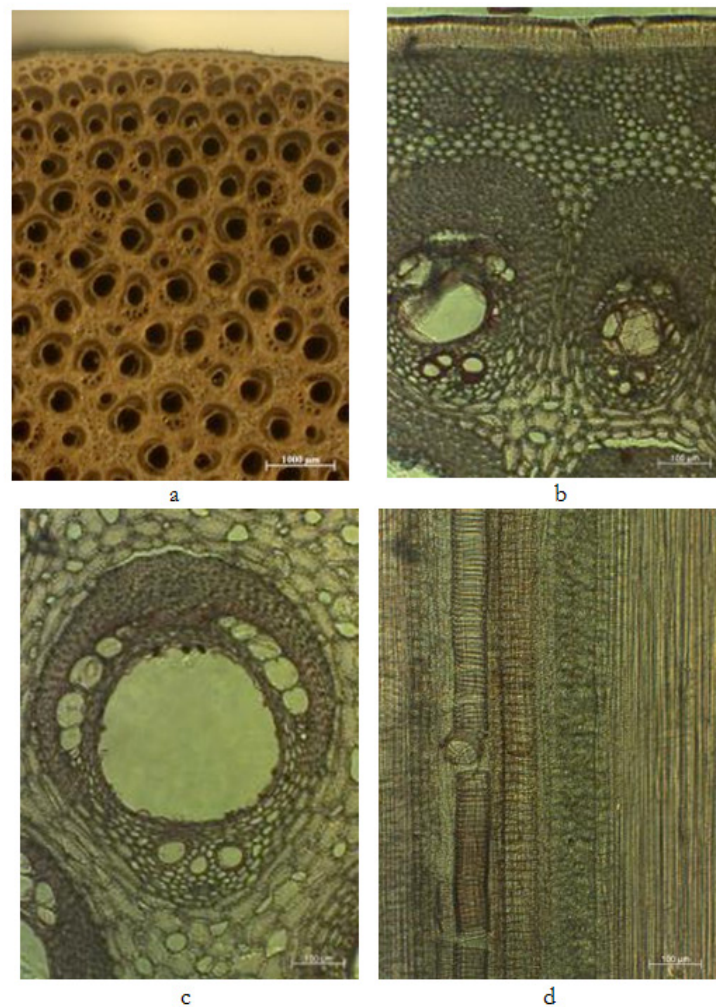
Figure 8. Anatomical structure of sijau rattan stem (*Calamus laevigatus* Martius)

Remarks: a. Stem cross section, scale 1000 μm; b. Stem cross section, scale 100 μm; c. Single vascular bundle, scale 100 μm; d. Lateral section, scale 100 μm

consists of a cluster 3–5 cells, with single cell diameter of 37.96 ± 5.17 μm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells (Figure 9c). Individual phloem cell diameter is about 49.62 ± 7.21 μm. Resin canal is distributed evenly in the ground parenchymatous tissue togteher with intercellular spaces.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner and outer parts. Fiber length is 2,126.57 ± 252.84 μm, width 19 ± 2.89 μm, lumen 10.59 ± 2.69 μm and wall thickness 4.2 ± 0.71 μm. Ground parenchyma cells are round to oval with varying sizes, type A.

I. Udang (*Korthalsia flagelaris* Miquel)

Single layer epidermis consisting of unlignified parenchyma cells and covered by siliceous layer. The epidermis layer is about 63.39 ± 6.25 μm and the endodermis layer is about 10.34 ± 4.43 μm. In the peripheral area, fiber bundles are arranged in one layer with no specific pattern. The peripheral area is about 208.67 ± 12.77 μm from the outer bark. Vascular bundle in the outer part is about 7–8 per mm², with the width and length (W/L) ratio is 0.97 ± 0.41, which means vascular bundle is approximately oval. Yellow cap is found in the top of outer vascular bundle, metaxyem vessel diameter is 142.81 ± 35.79 μm.
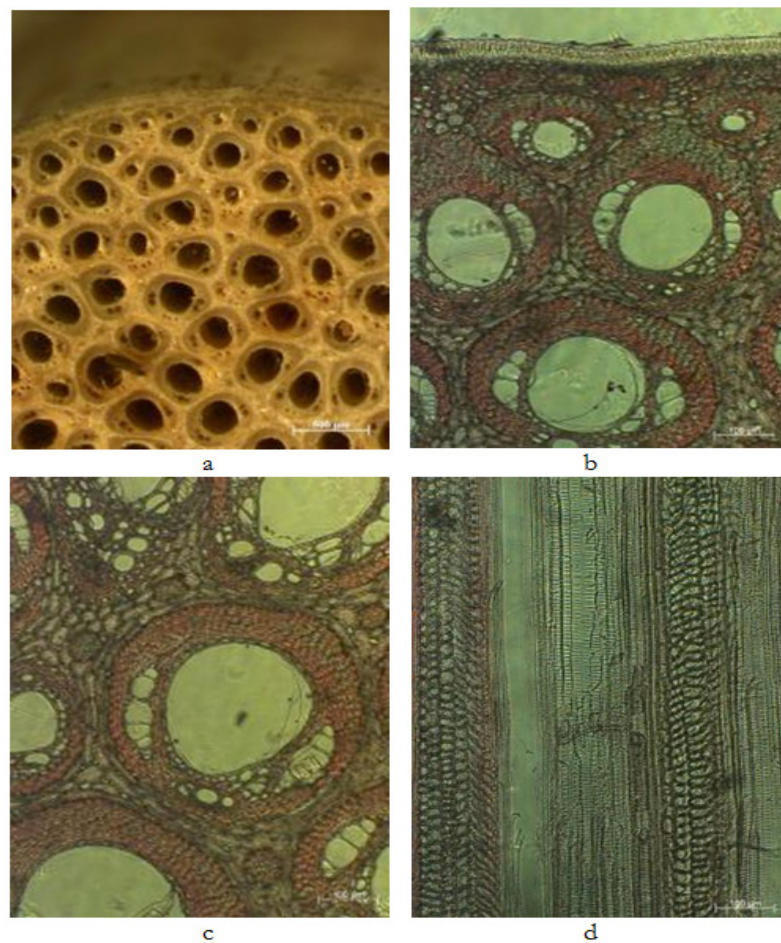
Figure 9. Anatomical structure of tunggal rattan stem (*Calamus laevigatus* Martius)

Remarks: a. Stem cross section, scale 1000 µm; b. Stem cross section, scale 100 µm; c. Single vascular bundle, scale 100 µm; d. Lateral section, scale 100 µm

As mostly found in monocotyledonous stem, vascular bundle in the inner part is greater in diameter than those of the outer part. The oval vascular bundle length and width is 673.72 ± 76.96 and 480.26 ± 68.17 µm, respectively. The vascular bundle in the inner part is 6–7 per mm², with the width and length (W/L) ratio is 0.73 ± 0.18. Metaxylem vessels are single, with diameter of 319.02 ± 33.74 µm. Protoxylem consists of a cluster 4–6 cells, with single cell diameter of 57.05 ± 5.81 µm. Phloem double stranded fields lying laterally to the metaxylem vessels and every field contains of 4–6 cells (Figure 10c). Individual phloem cell diameter is about 51.52 ± 8.87 µm. Resin canal diameter is 100.43 ± 15.84 µm.

Fiber sheath is mostly normal 'horse-shoe shaped' in inner part's vascular bundle and elongated in the outer part. Fiber length is 2,476.86 ± 332.08 µm, width 23.3 ± 2.8 µm, lumen 13.57 ± 1.94 µm and wall thickness 4.86 ± 1.05 µm. Ground parenchyma round to oval with varying sizes, type B.

As generally found in monocotyledonous, stem comprise a large central core of primary vascular bundles embedded in parenchymatous ground tissue, surrounded by peripheral area (cortex) (Butterfield & Meylan, 1980). The general stem anatomy of species investigated is similar with some Indonesian rattan species described by Jasni, Damayanti, and Kalima, (2012); Jasni, Damayanti, Kalima, Malik,
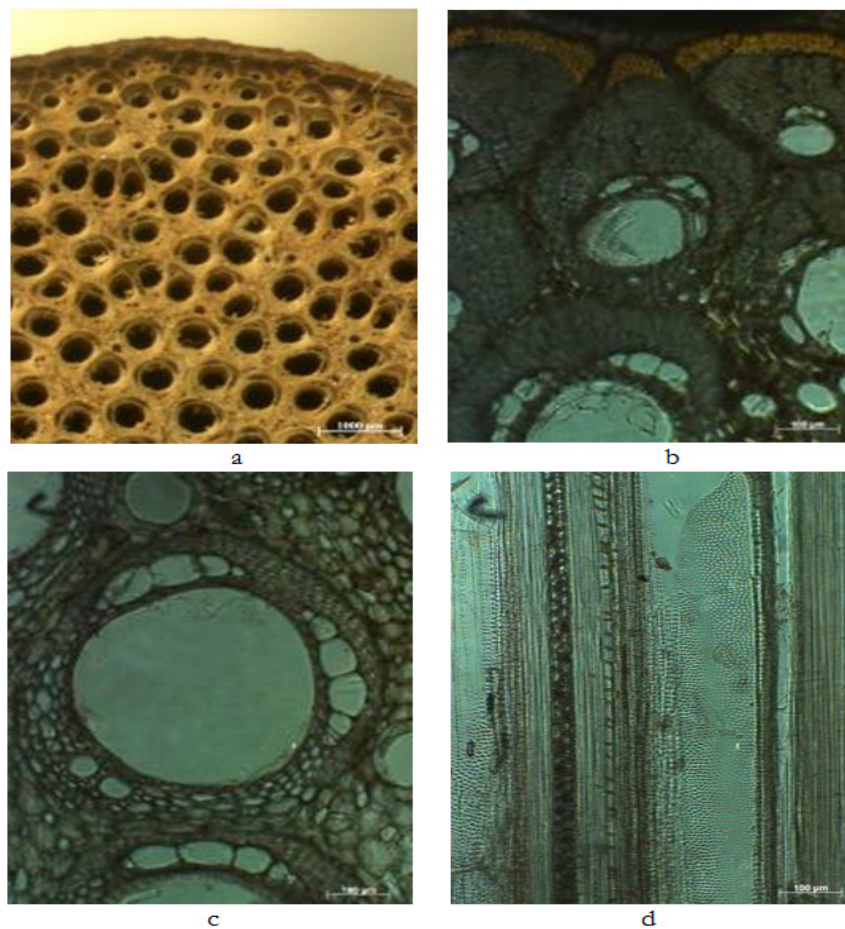
Figure 10. Anatomical structure of udang rattan stem (*Korthalsia flagelaris* Miquel)

Remarks: a. Stem cross section, scale 1000 μm; b. Stem cross section, scale 100 μm; c. Single vascular bundle, scale 100 μm; d. Lateral section, scale 100 μm

and Abdurachman, (2010); Jasni, Krisdianto, Kalima, and Abdurachman (2012). All species investigated were distinctly made up of epidermis, cortex and central cylinder. All species exhibited a single layer epidermis consisting of unlignified parenchyma cells. The epidermis was covered with siliceous layer interspersed with few stomata cells. The cortex or known as peripheral area consisted of fiber bands, undeveloped vascular bundles embedded in parenchyma cells of varying shapes and sizes structured ring-like in the outer part. Yellow cap which covers the top part of outer vascular bundle is found in opon (*Plectocomiopsis geminiflora* (Griff.) Beccari) (Figure 6b) and udang (*Korthalsia flagelaris* Miquel) (Figure 10b).

The central cylinder of all species was generally composed of vascular bundles of varying sizes and structure embedded in ground parenchyma. The vascular bundle consisted of conducting tissue (xylem and phloem), which was surrounded by fiber sheath and parenchyma. The xylem was mostly composed of one large metaxylem-vessel and a cluster of protoxylem-vessels. In some species investigated, tyloses-like was found in few metaxylem-vessels. The phloem consisted of different number of sieve tubes with companion cells. Ground parenchyma cells are round to oval with varying sizes, type A and B, as shown in longitudinal section appear like 'stacks of coins'. Tentative identification key to rattan species originated from Jambi is shown below.

1. Vascular bundles in the outer part of the stem
     a. yellow capped 2
     b. yellow cap absent 3
2. Metaxylem vessels in the inner part
     a. mostly in pair.................................opon (*Plectocomiopsis geminiflora* (Griff.) Beccari).
     b. mostly single ....udang (*Korthalsia flagelaris* Miquel).
3. Circle resin canals
     a. found in ground parenchymatous tissue 4
     b. not found 7
4. Resin canals
     a. in some area are found in pair ....getah (*Daemonorops micracantha* (Griff.) Beccari)
     b. exclusively single 5
5. Single resin canals
     a. are found in center part and in cortex/peripheral area ....batu (*Calamus zonatus*
        Beccari)
     b. are found in center part 6
6. Fiber bundles in the peripheral area
     a. is structured in one to two lines with no specific pattern ....paku (*Calamus*
        exillis Griff.)
     b. is structured in one line with alternate pattern ....duduk (*Daemonorops didymophylla*
        Beccari)
7. Fiber bundles in the central part
     a. are embedded in the ground parenchymatous tissue in between vascular bundle ..
        .... tunggal (*Calamus laevigatus* Martius)
     b. are not found separately from vascular bundle 8
8. Vascular bundles in the outer part
     a. are round to oval with W/L ratio is more than 1 .... sijau (*Calamus laevigatus*
        Martius)
     b   are oval to elongated with W/L ratio is less than 1 .... buruk
        ati (*Calamus insignis* Griff. var. *longispinosus* Dransfield)

Tentative identification key to rattan species above has been developed for nine species investigated from Jambi area, then the key should be developed for further genera identification among rattan species in Indonesia.

IV. CONCLUSION

Nine rattan species originated from Jambi were anatomically described for species identification purposes. The anatomical properties could become a diagnostic characteristic for rattan species identification and specific characteristic has been developed for key species determination. Vascular bundles in the outer part of the stem of opon and udang rattans are yellow-capped. Width and length ratio of vascular bundle in the outer part is less than 1, oval shape was found in sijau rattan, while elongated shape with the ratio less than 1 was found in buruk ati. Fiber bundles separated from vessels are found in central ground parencymatous tissue of rattan tunggal. In the peripheral area, fiber bundles forms one or two lines with no specific pattern found in paku rattan, while fiber bundles in one line with alternate pattern found in duduk rattan. Single resin canals are found both in center part and peripheral area is found in batu rattan and mostly single. Resin canals are found in pair at getah rattan stem. Tentative identification key to rattan species has been developed for nine species investigated, then the key should be developed for further genera identification among rattan species in Indonesia.

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