TOPIC 2

FOREST BIODIVERSITY
AND ECOSYSTEM SERVICES
Genetic Diversity of Six Populations of *Intsia bijuga* (Merbau) Assessed by SSR Markers

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Genetic Diversity of Six Populations of *Intsia bijuga* (Merbau) 
Assessed by SSR Markers

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ABSTRACT

Merbau (*Intsia bijuga*) is one of the most valuable timbers of South East Asia and has been heavily logged that threatened its sustainable utilization. The aim of the study was to examine genetic diversity of 6 populations from Maluku and Papua, for which such information would be useful to support conservation efforts. In this study, 59 alleles from 4 SSR primers previously developed for *I. palembanica* were used to investigate genetic diversity of the species. Number of alleles of the 4 primers varied between 8 to 19, indicating a high discriminating power of the selected primers. Mean genetic diversity was 0,762. Distribution of genetic diversity within population was higher (88%) than between populations (12%). Based on cluster analysis, the two geographic origins of Maluku and Papua are well separated. In the Papua populations there was a spatial differentiation. The implication of this study in the context of genetic conservation of the species is also discussed.

Keywords: merbau, genetic diversity, SSR, conservation

1. INTRODUCTION

Merbau (*Intsia bijuga*) is one of the most valuable timbers of South East Asia. The main utilization of merbau is for manufacture of exotic hardwood flooring. However, due to its durability and density, it is also widely used in exterior joinery, stairs and outdoor furniture, cabinet making, and exterior decking. Native distribution of merbau is spread in the western Pacific and Indo-Malaysian region, from New Guinea and Palau in the west to Fiji, Tonga and Samoa in the southeast, and to the Mariana, Caroline and Marshall Islands in the north and northeast in the Pacific. It is found in Madagascar, the Seychelles, Indonesia, Malaysia, Thailand, Philippines, Papua New Guinea, and Australia. In Indonesia, the species is naturally distributed from Sumatera to Papua (Verdcourt, 1979).

Nowadays, illegal logging of merbau has been widespread, especially in Papua. Since 2006 *Intsia bijuga* was classified as IUCN’s Red List of Threatened Species due to observed, inferred or projected habitat loss and over-exploitation.

Genetic diversity is fundamental to the overall survival mechanism of any species. Regeneration of degraded natural stands therefore should also use genetically diverse trees. By conserving diverse genetic resources of *Intsia bijuga*, the supply of plant materials for future use can be secured.

Molecular markers provide an important technology for evaluating levels and patterns of genetic diversity and have been utilized in a variety of plant species (Perera *et al*., 2000). Among the various DNA marker methods currently available that can be used to examine genetic diversity at the molecular level, the most informative polymorphic marker system to date is microsatellites, or SSRs (simple sequence repeats). Microsatellites, or simple sequence repeats (SSRs), represent a unique type of tandemly repeated genomic sequences, which are
abundantly distributed across genomes and demonstrate high levels of allele polymorphism. Microsatellite markers have been used to investigate genetic diversity of some plant species, such as coconut (Perera et al., 2000), Wheat (Huang et al., 2002), Teak (Dirmavena, 2007), and *Pinus merkusii* (Diputra, 2013).

The aim of this study was to investigate genetic diversity of six populations of *Intsia bijuga* (merbau) distributed in Maluku and Papua using SSR markers. This information will be used to support formulation of appropriate conservation strategy of the species.

2. MATERIALS AND METHODS

2.1 Materials

A total of 48 samples of individual trees from 6 populations of merbau distributed in Maluku and Papua were used in this study. At least 20 individual trees were collected for each population (represented all area of each population). However, in this study, only 8 individual trees per population were randomly selected and used for analyzing genetic diversity. The choice of 8 trees per population is based on the assumption of ease of laboratory practices as well as cost without compromising the accuracy of the results. Population name, province and number of sample per population were listed in Table 1. Detail location of each population was shown in Figure 1.

Table 1: Population of *I. bijuga* used in this study

<table>
<thead>
<tr>
<th>No.</th>
<th>Population</th>
<th>Province</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kaimana</td>
<td>West Papua</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Fak-fak</td>
<td>West Papua</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Biak</td>
<td>West Papua</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Jayapura</td>
<td>Papua</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Merauke</td>
<td>Papua</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Saumlaki</td>
<td>Maluku</td>
<td>8</td>
</tr>
</tbody>
</table>

2.1 Methods

Total genomic DNA was extracted using a modified Cetyl Trimethyl Ammonium Bromide (CTAB) protocol reported by Shiraishi and Watanabe (1995). PCR was performed in 10µl reaction mixture contained 10 ng/10µl template DNA, 0.125µM each of primers, 1.5 mM MgCl₂, 0.2 mM each of dNTPs, and 0.5 unit/10µl of AmpliTaq Gold Polymerase (Applied Biosystems). PCR was performed using a GeneAmp PCR System, Model 9700 (Perkin-Elmer). The condition of amplification was as follows: 120 s at 95°C, and 30 cycles of 30 s at 94°C, 30 s at 55°C, and 90 s at 72°C, followed by 300 s at 72°C. Amplified fragments were detected and sequenced using ABI 3100 genetic analyzer (Applied Biosystem)
Four SSR primers developed for *Intsia palembanica* (Wong *et al.*, 2009) were selected and used to analyze genetic diversity of *Intsia bijuga* based on the level of heretozygosity. Those primers were D20, D75, H16 and I18 (Table 2).

<table>
<thead>
<tr>
<th>No.</th>
<th>Primer</th>
<th>Repeat motif</th>
<th>Primer sequence (5’→3’)</th>
</tr>
</thead>
</table>
| 1   | D20    | (CT)13      | F: FAM-CGCAGGAATCTTAGACTCCACC  
R: CGAACAGTGCTTTCGCTTCCCG |
| 2   | D75    | (TC)14(CA)6 | F: FAM-CGACCTTTCCTCCCATCTC  
R: CATACTTGCACCATCTCGATCGC |
| 3   | H16    | (AG)16      | F: HEX-GCTCTAAAACACGCAATCGCC  
R: CAACTTTACGTGTCATGCGCTC |
| 4   | I18    | (GA)13      | F: HEX-GCTTTCAGCCATTGAAAACAAC  
R: TGTTGTATCATTCTAGCAATCCITCT |

Analysis of molecular variance (AMOVA) was used to partition the total genetic variance into components due to differences between regions, populations, and individuals. That was calculated using the software POPGENE 1.32 (Yeh *et al.*, 2000) and GenAlEx 6.5 (Peakall and Smouse, 2012).
3. RESULTS AND DISCUSSION

3.1 Genetic diversity

The four primer produced clear bands in electrophoresis using agarose gel. Numbers of alleles of the 4 primers varied between 8 to 19, less than number of alleles were obtained in *Intsia palembanica*. However, primer D20 produced more alleles in *Intsia bijuga*. A total of 59 alleles were obtained from the four SSR primers, and used to analyze genetic diversity of the six populations.

Based on the 59 alleles, expected heterozygosity of the six population was between 0.6130 and 0.8375. The highest genetic diversity was in Merauke population (0.8375) followed by Kaimana (0.8218) (Table 3). The smallest genetic diversity was in Saumlaki population (0.6130). Mean genetic diversity of the 6 populations was 0.7536.

Table 3: Genetic diversity parameters of the six populations

<table>
<thead>
<tr>
<th>Population</th>
<th>N</th>
<th>A</th>
<th>ne</th>
<th>$H_O$</th>
<th>$H_E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merauke</td>
<td>8</td>
<td>27</td>
<td>4.93</td>
<td>0.9062</td>
<td>0.8375</td>
</tr>
<tr>
<td>Fak-fak</td>
<td>8</td>
<td>26</td>
<td>4.38</td>
<td>0.6518</td>
<td>0.7850</td>
</tr>
<tr>
<td>Kaimana</td>
<td>8</td>
<td>35</td>
<td>6.18</td>
<td>0.8259</td>
<td>0.8218</td>
</tr>
<tr>
<td>Jayapura</td>
<td>8</td>
<td>30</td>
<td>5.10</td>
<td>0.6250</td>
<td>0.8187</td>
</tr>
<tr>
<td>Biak</td>
<td>8</td>
<td>25</td>
<td>5.16</td>
<td>0.5938</td>
<td>0.6458</td>
</tr>
<tr>
<td>Saumlaki</td>
<td>8</td>
<td>23</td>
<td>4.06</td>
<td>0.4509</td>
<td>0.6130</td>
</tr>
</tbody>
</table>

N: sample size, $A$: number of detected alleles, ne = Mean effective number of alleles [Kimura and Crow (1964)], $H_O$: observed heterozygosity, $H_E$: expected heterozygosity

Rimbawanto and Widyatmoko (2006) have reported genetic diversity and genetic relationship among 4 population of merbau using RAPD marker. Mean genetic diversity of the 4 population was 0.141. Yudohartono (2008) reported that genetic diversity of six population of merbau based on isozyme markers was 0.392. Higher genetic diversity revealed by microsatellite markers in this study recognized higher polymorphism of this marker compared to RAPD and isozyme. However, the 3 markers revealed high genetic diversity of *Intsia bijuga*.

3.2 Genetic Relationship between Populations

In order to clarify the genetic relationship among population, AMOVA and a UPGMA dendrogram were constructed from the genetic distances data. Genetic distance among regions and among populations were 3% and 12%, respectively (Table 4). The same result of genetic distance among populations also reported by Rimbawanto and Widyatmoko (2006).
According to the dendrogram, two distinct clusters were identified. The first cluster comprised of Merauke and Saumlaki populations, and the second cluster comprised of the remaining 4 populations (Fak-fak, Kaimana, Jayapura, Biak) (Figure 3). Grouping of the 6 populations did not reveal relation with geographic distance. Merauke and Kaimana are 2 populations located in different island and have the longest geographic distance compare with others populations. Higher variability of microsatellite marker can affect the clustering of populations based on geographic distance. Microsatellite marker is not a gene, thus the mutation is faster than gene markers.

![Dendrogram](image)

Information of genetic diversity and distribution, also genetic relationship between populations is important to develop strategy of conservation and breeding program of *Intsia bijuga*. From 6 populations used in this study, diversity of merbau is still high; meaning that the species can be conserved genetically and possible to improve for obtaining better individual trees. In order to collect genetic materials for establishing ex-situ conservation, the genetics materials should be collected as much as possible from within population, and also should be representative of each regions. High genetic distance among populations gives an opportunity to construct genetic data base of the *Intsia bijuga* populations for log tracking program of the species.
4. CONCLUSIONS

*Intsia bijuga* is restricted to the eastern part of Indonesia, mainly in the island of Papua and some parts of Maluku islands. Despite the limited distribution, our study found high genetic diversity of species. The pattern of genetic diversity of the species is typical of outcrossing species, high proportion of the diversity resides within population. Collection of genetic materials for conservation purpose should take into account this genetic diversity pattern in order to maintain high genetic diversity of the species.

5. REFERENCES


Composition of Bird Species at Plawangan, Gunung Merapi National Park

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Paper Prepared for
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Composition of Bird Species at Plawangan, Gunung Merapi National Park

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Faculty of Biology, Universitas Gadjah Mada. Matalabiogama.

ABSTRACT

Gunung Merapi National Park (GMNP) is located in Java island, around Merapi volcano, Indonesia. GMNP has some ecosystem types including tropical rain forest. One of tropical rain forest at Gunung Merapi National Park is located in Plawangan hill that was not affected directly by 2010's Merapi eruption. Plawangan has 3 main routes, they are: Tlogo Nirmolo, Tlogo Putri and Puncak. There was research about birds diversity due at April-Mei 2010 that taken in 2 routes (via Tlogo Nirmolo and Tlogo Putri). At 2012 it was conducted similar study in the aspect of birds diversity in Plawangan on three routes. It compares between two researches on two choosen routes and composition of bird species based on their feeding type. This study used point count method with 30 observation stations and taken twice for each station. The result of this study, found 45 species from 22 families. Shanon-Wiener index show 2.64 it mean at Plawangan has a medium diversity of bird. At 2012 were found 38 species in two routes, whereas at 2010 there were 70 species found. Twenty one species were refound at 2012. The birds grouped base on their feeding type. In Plawangan has six feeding type of bird: Insectivore, granivore, frugivore, nectarivore and omnivore. Insectivore compose 46.21% of bird community, carnivore 1.42%, granivore 24.85%, frugivore 5.006%, nectarivore 0.87% and omnivore 21.5%.

Keywords: Composition, Bird, Gunung Merapi National Park

1. INTRODUCTION

Gunung Merapi National Park (GMNP) is located in Java island-around Merapi volcano, Indonesia. GMNP has some ecosystem types, including tropical rain forest. One of tropical rain forest at Gunung Merapi National Park is located in Plawangan hill. Plawangan hill was not affected directly when Merapi volcano erupted in 2010. Plawangan has 3 main routes, they are: Tlogo Nirmolo, Tlogo Putri and Puncak.

At the route of Tlogo Nirmolo and Tlogo Putri, it is found that there are 70 bird species belonging to 28 families and 9 orders (Indriyani, 2010). Birds diversity can be an indicator of the quality of an area because birds are sensitive animal to environmental changes. Birds are animals that have a variety of feeding types that can be studied the link between food availability in nature with bird composition in the region. In this study we have 2 main questions, namely 1) how the comparation of bird diversity between recently condition with the data of 2010? And how does the composition based on the type of birds eating from bird species encountered?

2. METHODS

Plawangan forests are tropical rain forests that dominated by puspa (Schima wallichii). In general, the region has a wet tropical climate with rainfall between 2000-4000 mm (Binarwan, 2008). Nature Reserve has an area of 164.75 ha. Administratively, the area is located in Hargobinangun, Pakem, Sleman, Yogyakarta.
The research was conducted from 30th, August to 24th, November 2012 in the Plawangan Hill, Gunung Merapi National Park. This study used point count method. Bibby et al. (2000) stated that the method of bird census conducted by the marking of a place or a certain point. All of birds that found within a period of 10 minutes are noted on observation table. The observation then continued on the next point with a minimum distance of 100 m. Retrieval of data at 30 observation points. Each observation point was once repetition. Data collection was done between 08:00 to 15:00 pm.

The data was grouped based on taxa. The diversity of bird species was analysed using Shannon-Wiener index. The formula is:

\[
\text{Index Shannon-Wiener (H)} = \sum_{i}^N p_i \ln p_i \\
p_i = \frac{n}{N}
\]

where: \(n\) = number of individuals per species
\(N\) = total individuals of all species

Data set of bird species that found in this study was compared with the list of bird species that found from the study in 2010. Bird species was grouped based on the type of feed to calculate density value, group frequency and group importance. Composition is based on the importance of each group.

3. RESULTS AND DISCUSSION

The study show that there are 45 species of birds are scattered on the route Tlogo Putri, Tlogo Nirmolo and Puncak Plawangan (Table 1). The 45 bird species are belong to 22 familia and 8 Order

<table>
<thead>
<tr>
<th>No</th>
<th>Order</th>
<th>Family</th>
<th>Species name</th>
<th>Tlogo Nirmolo</th>
<th>Puncak Plawangan</th>
<th>Tlogo Putri</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Accipitriformes</td>
<td>Accipitridae</td>
<td>Pernis ptilorhyncus</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Apodidae</td>
<td>Collocalia esculenta</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Apodidae</td>
<td>Collocalia linchi</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Columbidae</td>
<td>Macrophygia emiliana</td>
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<td>yes</td>
<td></td>
</tr>
<tr>
<td>5</td>
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<td>Columbidae</td>
<td>Streptopelia bitonygata</td>
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<tr>
<td>6</td>
<td></td>
<td>Columbidae</td>
<td>Streptopelia chinensis</td>
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<tr>
<td>7</td>
<td></td>
<td>Coraciidae</td>
<td>Erythronus orientalis</td>
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<tr>
<td>8</td>
<td></td>
<td>Alcedinidae</td>
<td>Haliyon cyaniventris</td>
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<td></td>
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<tr>
<td>9</td>
<td></td>
<td>Coraciidae</td>
<td>Caomantia sepulralis</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Cuculidae</td>
<td>Cuculus saturates</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Campephagidae</td>
<td>Hemipus bishudinaceus</td>
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</tr>
<tr>
<td>12</td>
<td></td>
<td>Corvidae</td>
<td>Pericrocotus flameus</td>
<td>yes</td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Chloropsidae</td>
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<tr>
<td>14</td>
<td></td>
<td>Corvidae</td>
<td>Corvus enca</td>
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<td></td>
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<tr>
<td>15</td>
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<td>Dicuridae</td>
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<td>yes</td>
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<td>16</td>
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<td>Lonchura leucogastroides</td>
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<tr>
<td>17</td>
<td></td>
<td></td>
<td>Lonchura punctulata</td>
<td>yes</td>
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<td></td>
</tr>
</tbody>
</table>
The birds were found scattered in the three transects of observation. On the route of Tlogo Nirmolo, it was found 32 bird species and one of them is a migratory bird namely The Crested Honey Buzzard or *Pernis ptilorhyncus*. On the route of Puncak Plawangan it was found 15 species and on the Tlogo Putri route it was found 13 species. Thirty-two out of from 42 species in Plawangan Forest was only found in one transect, 11 species can be found in two different routes and two species found throughout the observation point, namely *Ficedula westermanni* and *Lophozosterops javanicus*. Both of these bird species is commonly found in the region. *Ficedula westermanni* also a cosmopolitan bird or birds that have vulnerable habitats (Sulistyadi, 2010)

In this study the data compared with the list of data species found from the study in 2010, as shown in Table 2.

Table 2: Comparison of bird Species in the study in 2010 and 2012
<table>
<thead>
<tr>
<th>No</th>
<th>Species name</th>
<th>2010</th>
<th></th>
<th>2012</th>
<th></th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td>Tlogo</td>
<td></td>
<td>Tlogo</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nirmolo</td>
<td></td>
<td>Putri</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tlogo</td>
<td></td>
<td>Tlogo</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nirmolo</td>
<td></td>
<td>Putri</td>
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</tr>
<tr>
<td>10</td>
<td>Arachnothera longirostra</td>
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<td></td>
<td>✓</td>
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<td>11</td>
<td>Cacomantis merulinus</td>
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<td>Cacomantis sepu</td>
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<td>Chloropsis sonnerati</td>
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<td>Collocalia esculenta</td>
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<td>Collocalia linobi</td>
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<td>✓</td>
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<td>Copysychus malabaricus</td>
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<td>Copysychus sullaris</td>
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<td>Cuculus saturates</td>
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<td>24</td>
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<td>Dicaeum trigonostigma</td>
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<td>Dicaeum trochileum</td>
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<td>Dicrurus leucopus</td>
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<td>Eudynamys scolopacea</td>
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<td>Ezurnystomus orientalis</td>
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<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>31</td>
<td>Ficedula hyperiba</td>
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<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>32</td>
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<td>Gallus varius</td>
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<td>Haleyon cyanovenetris</td>
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<td></td>
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<td>Hemipus birudinacens</td>
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<td>36</td>
<td>Ictiniaetus malayensis</td>
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<td></td>
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<tr>
<td>37</td>
<td>Iole virescens</td>
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<td>Megalaima armilaris</td>
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<td></td>
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<td>Megalaima javensis</td>
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<td>Megalaima lineata</td>
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</tr>
<tr>
<td>47</td>
<td>Megalaima sp.</td>
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<td>Muscicapa danurica</td>
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</tr>
<tr>
<td>49</td>
<td>Muscicapa ferrugineae</td>
<td>✓</td>
<td></td>
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</tr>
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<td>Myiophonus glucinus</td>
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<td></td>
<td>✓</td>
<td></td>
</tr>
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<td>51</td>
<td>Nectarinias jugularis</td>
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<td>52</td>
<td>Oriolus chinensis</td>
<td>✓</td>
<td></td>
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<td></td>
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<tr>
<td>53</td>
<td>Orthotomus ruficaps</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Parus major</td>
<td>✓</td>
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<td>55</td>
<td>Pellorneum capistratum</td>
<td>✓</td>
<td></td>
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<tr>
<td>56</td>
<td>Pericrocotus flammens</td>
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<td></td>
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<tr>
<td>57</td>
<td>Phylloscopus coronatus</td>
<td>✓</td>
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<td></td>
</tr>
<tr>
<td>58</td>
<td>Phylloscopus trivirgatus</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Pnoepyga pusilla</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Pomatorhinus montanus</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Psittacula alectandra</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
In a study in 2010 it was found 29 families which consists of 70 species on the Tlogo Nirmolo dan Tlogo Putri. Meanwhile, from the study in 2012 it was found on the same track 20 families with 34 species. In a study in 2012 it was found 10 new species Plawangan. Means that there are 24 species found in the study in 2010 and still exist until 2012. The species that are found always at the observation point both in research studies in 2010 and 2012 are Eumyias indigo, Pycnonotus aurigaster and Lonchura leucogastroides. These three species are cosmopolitan bird or birds that have vulnerable habitats (Sulistyadi, 2010).

There are 39 species of birds that found from study in 2010 but then they were not found in 2012. This is caused by several factors: first, the study in 2010 and in 2012 performed at different times vulnerable i.e. in April-May 2010 and September-November 2012. The second is due to vulnerable period of transition season, In the April-May is the season heading into the dry season, while in the month of September-November is the rainy season cause Forest region at Plawangan frequent heavy fog and rain. At the time of dense fog birds difficult to be observed because of limited visibility in the rain. In addition birds are more prone to hiding in the branches that sheltered or returning to the nest.

Shannon Wiener index is used to analysed bird diversity. The analysis show that In Plawangan, bird diversity was moderate level that shown by index of 2.64. For each transect it was also been anlayzed the diversiry index, with the result are 1.19; 0.73, and 1.014 respectively for Tlogo Nirmolo Puncak Plawangan and Tlogo Putri.

The birds that found in Plawangan in 2012 classified by its feeding type, there are 6 groups. As presented in Figure 1.
In Plawangan it was found 6 groups of bird feed that are carnivorous, frugivores, granivora, insectivores, omnivores and nectarivora. Carnivorous are group of birds that consume meat; frugivores birds consume several kinds of fruits; granivora consume grains; insectivores consumes insect; omnivorous consume both meats and vegetable, and nectarivora consume nectar. Insectivores is the largest group among other five groups. It is indicated that in the area of study there are large number of insects provided as bird feed. It is also indicated that Plawangan has a diverse insect species. It is prove that there are various types’ of birds with different types of feed. So, it is an indication that the bird habitat in Plawangan is quite good.

4. CONCLUSIONS

From this study, it can be concluded that the diversity of bird species in the Plawangan is high enough. Based on the bird taxon there are 45 species of birds belong to 22 families and 8 order. Based on Shannon-Wiener index, it is indicated that Plawangan Forest has moderate diversity index. In 2012, it was found 38 species of birds that are on the Tlogo Putri and Tlogo Nirmolo route, while in 2010 there were 70 species of birds found in the same path. Based on type of feed, birds in Plawangan Forest was dominated by insectivores.

5. REFERENCES


Tree Breeding of *Araucaria cunninghamii* for Increasing Its Growth at Bondowoso Trial

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Breeding of *Araucaria cunninghamii* for Increasing Its Growth at Bondowoso Trial

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ABSTRACT

*Araucaria cunninghamii* is one of the species having a high potential for various uses. *A. cunninghamii* wood has been used for a wide range of use, such as paper and pulp, plywood, veneer, panel, flooring, carpentry and wood frame. Progeny test of *A. cunninghamii* was established at Bondowoso, East Java in 2001 to improve growth. Number of families in the progeny trial were 28 families in 3 provenances from Papua, i.e. Nerwah, Puan and Tumbii.

The study showed that productivity of these provenance is 116.77 m³/ha in the age of 11 years. The increment of volume is 10.62 m³/ha/year. The trend of mean annual increment (MAI) in the progeny always increase each year (1 year old to 11 years old). The information will be useful to make a breeding strategy of *A. cunninghamii*.

Keywords: *Araucaria cunninghamii*, growth, tree breeding, productivity

1. INTRODUCTION

*Araucaria cunninghamii* grows in Australia and New Guinea including Papua New Guinea and the Indonesian province of Papua. In Australia, the species grows in tropical coastal regions and sub-tropical rain forest, from Northern Queensland to Coffs Harbour, at an altitude of 0-1000 m asl (Nikles 1996). Natural forest of *A. cunninghamii* in Papua Island were at the River Saga Aho at Milne Bay in Papua New Guinea at latitude 10°01’ South and longitude 15°015’ East longitude with an altitude of 550-900 m above sea level and in Papua Vogelkop Sausapor at South 0°03’ South and 132°05’ East. In the province of Papua, spread covers Wamena, Jayapura, Nabire, Serui, Fak-Fak, Sorong and Manokwari (FPK-UNCEN, 1980).

The *A. cunninghamii* stem is a cylindrical, height of the species was 40 m and diameter was up to 4 m. Branches wretched with leaves petals (bunches) in the tassels on the ends. Attached leaves do not easily fall, scaly leaf shape, sharp edge, not winged seeds, united with the cone scales. *A. cunninghamii* has multipurpose *i.e.* softwood consumption, including for the pole and the building, plywood, furniture (tables, chairs, household items, home furnishings, furniture, carpentry), molding, flooring, plank, ship building, container, particle board and paper board, pulp and paper (Dean et al., 1988). Wood properties and extraordinary texture uniform, brownish yellow, and high utility value, putting this kind of as the most preferred wood for building. *A. cunninghamii* is the main raw material for sawmills and plywood industry in Papua New Guinea.

During Dutch colonization, the species was planted for large scale forest plantation of *A. cunninghamii* in Kebar, Papua to support of plywood, pulp and paper industries. In 1961 to 1962, the area plantation was about 1,000 ha in Kebar and Prafi. In 1963, the plantation program was not continued by the Dutch (Kapisa, 2002). Now, Forest communities are not interest to develop the plantation of *A. cunninghamii*.  

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The problem in *A. cunninghamii* forest are illegal logging for agriculture conversion and other purposes or forest fire. The problem will reduced genetic diversity and the genetic base will be decrease. This condition lead us to improve breeding activities of this species in the future.

The government has an intensive silviculture on establishment the plantations forest program. While existence of natural tropical forest maintained to obtain high forest benefits, for example to provide *Araucaria* orchard seed. Genetic source of *A. cunninghamii* is in Papua New Guinea and Papua that was used on development of plantations forest.

Intensive breeding program has been carried out in Queensland for this species since about 1950 (Nikles 1996). The real genetic improvement has gained about 20%, whereas the same species breeding efforts in Papua New Guinea have not provided significant benefit for the industry. Meanwhile, the study of genetic variation of *A. cunninghamii* have not been conducted. Center for Biotechnology and Forest Tree Improvement Research Yogyakarta has designed and established *A. cunninghamii* progeny in 2008 in Bondowoso, East Java. The trial will be use to study stem growth trend and genetic improvement for the volume increment.

2. MATERIALS AND METHODS

2.1 Progeny Test of *A. cunninghamii*

This site study is located in Forest Research Area (KHDTK) of The Center for Biotechnology and Forest Tree Improvement Research in Bondowoso which was lied on 07°59'56"S-114°00'09.6"E. Administratively, the research forest is located in Wringin Anom village, Sub-district Sukosari, Bondowoso, East Java. The site has type B of climate with average rainfall of 2400 mm/year. Rainy season in during November to April with the lowest temperature 17°C and the highest temperature 30°C. The type soil is andozol. The slope is flat. The altitude is about 800 m above sea level.

The progeny test of *A. cunninghamii* was established in 2002. The trial was designed using completely randomized block design (CRBD) consisting of 80 families by using 4 replicates (4 blocks), 4 trees each plot (4 tree plot), with a spacing was 4 x 2 m. The parameter to be measured in this study are height, diameter, and stem volume in every year. The Data source and amount of seed families used in this study are presented in Table 1.

Table 1: Seed information of progeny test of *A. cunninghamii* at Bondowoso trial

<table>
<thead>
<tr>
<th>Family</th>
<th>Provenance</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P12 – Nerwah II (Papua)</td>
<td>01° - 05'</td>
<td>133° - 01'</td>
<td>1250</td>
</tr>
<tr>
<td>2</td>
<td>P1 - Nerwah II (Papua)</td>
<td>01° - 10'</td>
<td>133° - 12'</td>
<td>1250</td>
</tr>
<tr>
<td>3</td>
<td>P2 - Nerwah II (Papua)</td>
<td>01° - 21'</td>
<td>133° - 19'</td>
<td>1200</td>
</tr>
<tr>
<td>4</td>
<td>P3 - Nerwah II (Papua)</td>
<td>01° - 28'</td>
<td>133° - 24'</td>
<td>1200</td>
</tr>
<tr>
<td>5</td>
<td>P4 - Nerwah II (Papua)</td>
<td>01° - 34'</td>
<td>133° - 31'</td>
<td>1300</td>
</tr>
<tr>
<td>6</td>
<td>P7 - Nerwah II (Papua)</td>
<td>01° - 40'</td>
<td>133° - 38'</td>
<td>1300</td>
</tr>
<tr>
<td>7</td>
<td>P8 - Nerwah II (Papua)</td>
<td>01° - 51'</td>
<td>133° - 43'</td>
<td>1300</td>
</tr>
<tr>
<td>8</td>
<td>P9 - Nerwah II (Papua)</td>
<td>01° - 59'</td>
<td>133° - 47'</td>
<td>1300</td>
</tr>
<tr>
<td>9</td>
<td>P11-Nerwah II (Papua)</td>
<td>01° - 64'</td>
<td>133° - 55'</td>
<td>1300</td>
</tr>
<tr>
<td>10</td>
<td>P1 – Puan (Papua)</td>
<td>04° - 01'</td>
<td>132° - 04'</td>
<td>1200</td>
</tr>
<tr>
<td>11</td>
<td>P2 – Puan (Papua)</td>
<td>04° - 07'</td>
<td>132° - 11'</td>
<td>1200</td>
</tr>
<tr>
<td>12</td>
<td>P3 – Puan (Papua)</td>
<td>04° - 12'</td>
<td>132° - 09'</td>
<td>1300</td>
</tr>
<tr>
<td>13</td>
<td>P4 – Puan (Papua)</td>
<td>04° - 18'</td>
<td>132° - 14'</td>
<td>1300</td>
</tr>
</tbody>
</table>
2.2 Measurement and Data Analysis
Measurements carried out on tree height and trunk diameter ranging from age 1 year to 11
trees. Estimated volumes of tree \textit{A. cunninghamii} calculated using the formula:

\[ V = (3.14) h \cdot d^2 \cdot f \]

Where 
- \( V \) = Volume (m3) 
- \( h \) = tree height (m) 
- \( d \) = diameter at 1.3 cm above the ground 
- \( f \) = form factor

3. RESULTS AND DISCUSSION

3.1 Survival of the \textit{A. cunninghamii}
Ability to grow and plant adaptation to environmental conditions where growth can be
observed in real based on the criteria of survival. Observation of the survival rate in the field is
done by counting the number of died tree in every family in each block. On the progeny test of
\textit{A. cunninghamii} in Bondowoso, East Java, in the form of percent survival, suggesting that
survival was about 90\% to 100\%. Razak (1991) reported that the survival rate was 96\%showed by
\textit{Araucaria} plantation in Sungai Buloh, Peninsular Malaysia on the age of 30 months
after planting, \textit{A. cunninghamii} is quite advantage in adapting to different environmental.
Eissemann \textit{et al.} (1990) reported that survival of test \textit{A. cunninghamii} progeny test in 15 years
was 95\%. The high survival above 90\% was good indicator for the species (Na’iem, 2004).
The result of investigation of survival of the progeny test of \textit{A. cunninghamii} in Bondowoso was
high, so the progeny test can be develop to research in future.

3.2 Trend of Growth
A trend of growth for high and and diameter in progeny test \textit{A. cunninghamii} up to age 11 years
in study site was showed in Figure 1 and 2. Height and diameter are important trait to be
improved by selection program to achieve high genetic gain.

Growth is basically a variety of physiological processes that occur in the body of the plant,
which also reflects the role of genetic factors that are always passed down through the
generations from parent to offspring and environmental factors in the region grows and
develops plants (Zobel and Talbert, 1984). Mean of heigh in the progeny test of *A. cunninghamii* at Bondowoso, East Java in 11 years was 9.32 m and mean of diameter was 12.49 cm diameter. Xu *et al.* (2002) reported that mean of height *A. cunninghamii* in 18 months after planting in Queensland, Australia was 2.07 m and the diameter was 3.24 cm. Result of research in *A. cunninghamii* provenance test in 5 years old in Luiz Antonio-SP, Brazil showed that height was 6.37 m and the diameter was 7.79 cm (Sebbenn *et al.* 2005). Harding *et al.* (1991) measured *A. cunninghamii* in Queensland in 15 years old that mean of height was 15.45 m and diameter was 17.45 cm. The research of hunsteinii *Araucaria* species in Peninsular Malaysia in 17 years old showed that mean height was 23.9 m and diameter was 19.8 cm (Zuhaidi *et al.* 1996). The difference of growth was caused by difference of environmental of site (altitude or others). The progeny test of *A. cunninghamii* in Bondowoso, East Java was lower (800 m asl) then altitude of the source of seed collected. Besides environment site factor in the growth competition between plants, the role of the manager also determines its success of the growth of the species (Alrasjid, 1991).

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**Figure 1:** Trend of height in the progeny test of *A. cunninghamii* in Bondowoso trial

**Figure 2:** Trend of diameter in the progeny test of *A. cunninghamii* at Bondowoso trial
3.3 Trend of Volume

Volume of trees for forest plantation is very important, because volume is standard of wood demand. The result of analysis showed that stem volume of *A. cunninghamii* in the progeny test in 11 years old was 116.77 m$^3$/ha. The Figure 3 showed that the trend of growth for stem volume always increase each year from 1 year old to 11 years old. The progeny trial should be selected to obtain the best growth tree in the best families. The genetic gain for volume will be high gain by tree selection.

![Figure 3: The trend of stem volume in the progeny test of *A. cunninghamii* at Bondowoso trial, East Java](image)

The result of analysis for mean annual increment (MAI) showed that MAI of *A. cunninghamii* in the progeny test in 11 years old was 10.62 m$^3$/ha/year. The Figure 4 showed that the trend of MAI for stem volume always increase each year from 1 year old to 11 years old. MAI of the progeny test was 4.56 m$^3$/ha/year in 9 years old, 7.45 m$^3$/ha/year in 10 years old and 10.62 m$^3$/ha/year in 11 years old. The age of the progeny trial affects in the volume increment, it was indication that age has to decide to conduct tree selection for the species to get high MAI.

![Figure 4. Trend of MAI in the progeny test of *A. cunninghamii* at Bonwoso trial, East Java](image)
4. CONCLUSION

The progeny trial of *A.cunninghamii* in Bondowos East Java can improve MAI using tree selection in the breeding.

5. REFERENCES


Na'Iem, M., 2004. Genetic testing is a fundamental element in the tree breeding activities of bald hills up to Wanagama I.Yayasan Means Wanajaya, Jakarta.


Chloroplast DNA Sequences and $PgiC$ Nuclear Region

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Molecular Phylogeny of Moluccan Shorea Species Inferred from Chloroplast DNA Sequences and PgiC Nuclear Region

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ABSTRACT

A large family of massive trees, Dipterocarpaceae is a dominant and important timber species found in tropical forests. The family includes over 500 species in 17 genera. Previously, general identification is based on morphology, wood anatomy, palynology, and fossil record. However, more recent years the use of DNA as molecular marker is suitable for discriminating closely related species. Shorea selanica and Shorea assamica ssp. koordersii are species within the genus Shorea, which grow in easternmost-range of distribution in Dipterocarpaceae. S. selanica are known as endemic species only found in Moluccas islands, while S. assamica ssp. koordersii are found in wider area including Sulawesi and the Philippines and grouped in Shorea White Meranti. The objective of the study is to confirm the phylogenetic position of Shorea selanica and Shorea assamica ssp. koordersii revealed both by cpDNA and PgiC nuclear regions. We collected four samples of S. selanica originated from Arboretum Conservation and Rehabilitation of Research and Development Center, while three samples of S. assamica ssp. koordersii were collected spanning their distribution in Moluccas islands. Three chloroplast DNA regions: trnL-trnF, trnH-trnK, psbC-trnS, and one nuclear PgiC region were determined for constructing molecular phylogeny of the Moluccan Shorea species. Alignment of the matrix used of phylogenetic analysis for chloroplast regions contained 4363 bp while for nuclear regions contained 1638 bp. As expected based on taxonomic classification, S. selanica was nested within the Red Meranti clade, while S. assamica ssp. koordersii was within the White Meranti clade.

Keywords: Molecular Phylogeny, Moluccan shorea, Chloroplast DNA,

1. INTRODUCTION

A large family of massive trees, Dipterocarpaceae is a dominant and important timber species found in tropical forests. The family includes over 500 species in 17 genera and is divided into three subfamilies: Monotoideae, Pakarimoideae, and Dipterocarpoideae (Ashton, 1982). Only subfamily Dipterocarpoideae is found in Indonesia with nine genera (Anisoptera, Catylelobium, Dipterocarpus, Dryobalanops, Hopea, Parasoreia, Shorea, Upuna, and Vatica) and more than 250 species (Ashton 1982). Shorea is the largest and economically most important genus of Dipterocarpaceae, encompasses about 200 species in 11 sections, of which 163 species are distributed in Malesia, mostly in Indonesia, in particular on Sumatra and Borneo (Kalimantan), while genus Hopea comprises more than 100 species. The genus Shorea has been divided into four sections (Shorea, Rubroshorea, Richetoides, and Anthosoreia), which closely follow the four color-based types of timber designated for commercial purposes, i.e., Balau, Red Meranti, Yellow Meranti and White Meranti (Symington, 1943).
Identification of species in this family is not an easy task because some characteristics vary with age of the tree and their habitats (Symington, 1974). Previously, general identification is based on morphology, wood anatomy, palynology, and fossil record (Ashton, 1980). However, more recent years the use of DNA as molecular marker is suitable for discriminating closely related species. The advantage of DNA-based markers is that they are not influenced by the environment or by the developmental stage of the plant.

The phylogeny of the Dipterocarpaceae has been assessed using several kind of molecular methods, such as PCR-RFLP analysis of chloroplast genes (Tsumura et al., 1996; Indrioko et al., 2006), sequence analysis of cpDNA regions (Kajita et al., 1998; Kamiya et al., 1998; Dayanandan et al., 1999), sequence analysis of nuclear genes region (Kamiya et al., 2005), and AFLPs (Cao et al., 2006). The study by Tsumura et al. (2011) using chloroplast sequence data and Kamiya et al. (2005) using PgiC nuclear gene successfully resolved fully taxonomy and systematic of the representatives species for the genus *Shorea*. However, the study mostly focused on Borneo and Malayan dipterocarps species and further sequence data are required to cover greater range of species in this genus.

*Shorea selanica* and *Shorea assamica ssp. koordersii* are species within the genus *Shorea*, which grow in easternmost-range of distribution in Dipterocarpaceae. *S. selanica* (botanical section: *Brachypterae*) are known as endemic species only found in Moluccas islands, while *S. assamica ssp. koordersii* (botanical section: *Anthoshorea*) are found in wider area including Sulawesi and the Philippines and grouped in *Shorea* White Meranti (Ashton 1982). *S. selanica* (botanical section: *Brachypterae*) grows naturally in lowland forest on well drained land with fertile soils. It has medium size nuts (ca. 15 × 9.8 mm) and the wood belongs to the light *Shorea* Red Meranti group (Ashton 1982). Their edge of distribution has attracted geneticists in studying both evolutionary history and phylogeny study. While many studies have been conducting for many dipterocarps in their center of biodiversity, little is known for the species growing in their peripheral distribution. This study was conducted to determine the phylogenetic position of two Molllucan Shorea species, *Shorea selanica* and *Shorea assamica ssp. koordersii*, revealed both by cpDNA and nuclear PgiC region.

### 2. EXPERIMENTAL METHODS

#### 2.1 Plant Materials

We collected four samples of *S. selanica* originated from Arboretum Conservation and Rehabilitation of Research and Development Center (S 06°35'45.8'' E 106°46'54.1''), while three samples of *S. assamica ssp. koordersii* were collected spanning their distribution in Moluccas islands. We used DNA sequences of *trnL-trnF*, *trnH-trnK*, and *psbC-trnS* in various *Shorea* species from previous studies by Tsumura et al. (2011), while nuclear PgiC sequences were taken from Kamiya et al. (2005). A matrix using both cpDNA regions and nuclear PgiC were constructed with seven individuals of Moluccan *Shorea* species in this study. Genomic DNA was extracted using CTAB method by Doyle and Doyle (1990).

#### 2.2 Molecular Methods

Three chloroplast DNA regions (*trnL-trnF*, *trnH-trnK*, *psbC-trnS*) and one nuclear PgiC region (see Table 1) were determined for the Moluccan *Shorea* species. Primers used for each region were described in Table 4.1. The PCR was performed in 25 μl of reaction mixture containing 10 ng genomic DNA, 1 × PCR buffer for KOD-plus, 2.5 mM MgSO₄, 0.2 mM dNTPs, 0.1 M of each primer, and 1U of KOD-Plus- DNA Polymerase (TOYOBO, Japan). We applied touchdown PCR profile: initial denaturation was performed at 94°C for 2 min followed by 4
cycle of 45s at 94°C, 45s at 59°C and 2.5 min at 68°C (subsequently lowering the annealing temperature by 1°C per cycle); 26 cycles of 45s at 94°C, 45s at 55°C, and 2.5 min at 68°C. Prior to sequencing, the PCR products were purified using rAPid Alkaline Phosphatase™ (Roche, Germany) and ExonucleaseI (New England Biolabs, Massachusetts, USA). The PCR products for PgiC nuclear gene were cloned with a pGEM – T easy Vector System (Promega, Madison, Wisconsin, USA) following the manufacturer’s protocol. We sequenced eight independent clones for each individual or 56 sequence in total. By this method we got at least two independent clones for every haplotype to avoid PCR artifacts. DNA sequencing both for cpDNA region and PgiC clones were performed using an ABI Big Dye Terminator Cycle v3.1 Sequencing Kit and an ABI PRISM 310 Genetic Analyzer (Applied Biosystems).

Table 1: Primers used in the analysis

<table>
<thead>
<tr>
<th>Region</th>
<th>Name</th>
<th>Sequences (5’ – 3’)</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>trnL–trnF</td>
<td>c</td>
<td>CGAAATCGGTAGACGCTAACG</td>
<td>Taberlet et al., 1991</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>ATTTGACTGGTGACACGAG</td>
<td>Taberlet et al., 1991</td>
</tr>
<tr>
<td>trnHK-F</td>
<td></td>
<td>ACGGGAATTGAACCGCGCA</td>
<td>Demesure et al., 1995</td>
</tr>
<tr>
<td>trnHK1</td>
<td></td>
<td>ACCGATAGCTGCAGAAGTAGGA</td>
<td>This study</td>
</tr>
<tr>
<td>trnHK2</td>
<td></td>
<td>TGTCACCAATAACCAATATCAA</td>
<td>This study</td>
</tr>
<tr>
<td>cp5iF1</td>
<td></td>
<td>TTTTCGTTGTTTTCCCTGAT</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp5iF2</td>
<td></td>
<td>GCRATGAAGGCRATAATAAA</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp5iR1</td>
<td></td>
<td>TGCTCAAYAACCTTTCCCTTA</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp5iR2</td>
<td></td>
<td>TCCCTATTCTAGTGCTATGC</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp5iR3</td>
<td></td>
<td>CCGCAACTTCTGTATTTAAT</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>psbC-F</td>
<td></td>
<td>GGTCGTGACCAAGAAACCAC</td>
<td>Demesure et al., 1995</td>
</tr>
<tr>
<td>trnS-R</td>
<td></td>
<td>GGTCGGATCCCTCCTCTCTC</td>
<td>Demesure et al., 1995</td>
</tr>
<tr>
<td>cp6iF1</td>
<td></td>
<td>TGGAGGAGAGAGGATGGATGTG</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp6iF2</td>
<td></td>
<td>GCCACCTCTCATTTTGTTCCT</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp6iR1</td>
<td></td>
<td>ACACCTACCATCTACATTAC</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>cp6iR2</td>
<td></td>
<td>CCCAGAACAAATGAGAGGTTG</td>
<td>Tsumura et al., 2011</td>
</tr>
<tr>
<td>PgiCF3</td>
<td></td>
<td>CATTTCTATTCAGCCACCTTT</td>
<td>Kamiya et al., 2005</td>
</tr>
<tr>
<td>PgiCR4</td>
<td></td>
<td>ATTAGATGCTTGGAACATTCTC</td>
<td>Kamiya et al., 2005</td>
</tr>
<tr>
<td>PgiC2F</td>
<td></td>
<td>TTTCTGGATAGCCACCAAAGG</td>
<td>Kamiya et al., 2005</td>
</tr>
</tbody>
</table>
2.3 Data Analysis

DNA sequences were checked visually and forward and backward traces were assembled using the ATGC program (Genetyx Corporation, Japan). For cpDNA sequences, a molecular phylogenetic tree was constructed using the neighbor-joining (NJ) method (Saitou and Nei 1987) to test for clustering according to wood groups, which are defined according to color—Red Meranti, Yellow Meranti, White Meranti and Balau (Symington 1943)—and are monophyletic, based on previous study by Tsumura et al. (2011). While for PgiC nuclear sequence, the methods based on previous study by Kamiya et al. (2005). The robustness of the resulting phylogenetic tree was tested by bootstrap analysis (Felsenstein 1985) with 1000 replicates using MEGA5 software (Tamura et al. 2011).

3. RESULTS AND DISCUSSION

3.2 Results

Alignment of the matrix used of phylogenetic analysis for chloroplast regions contained 4363 bp. Figure 1 showed NJ trees from chloroplast DNA regions. The analysis using Anisoptera laevis as an outgroup identified clades for Shorea Red Meranti, Shorea Balau, Shorea Yellow Meranti, Shorea White Meranti, and others genera including Neobalanocarpus and Hopea. All four Shorea clades are supported by more than 90% of bootstrap values. As expected based on taxonomic classification, S. selanica was nested within the Red Meranti, while S. assamica ssp. koordersii was within the White Meranti clade.

Alignment of the matrix used of phylogenetic analysis for nuclear regions contained 1638 bp. Figure 2 showed NJ trees from nuclear PgiC gene. The analysis using Dipterocarpus palembanicus as an outgroup also identified clades for Shorea Red Meranti, Shorea Balau, Shorea Yellow Meranti, Shorea White Meranti, and a clade for Hopea and other genera. The four individuals of S. selanica based on nuclear PgiC sequences are grouped into the clade of Shorea Red Meranti. This phylogenetic relationship is in agreement with previous result from cpDNA sequences and present taxonomic treatment (Ashton 1980, 1982). In this study we also determined that S. selanica is monophyletic. S. assamica ssp. koordersii was grouped within Shorea White Meranti clade and it is also consistent with its taxonomic classification.
Figure 1: Phylogenetic position of *S.selanica* and *S. assamica* ssp. koordersii as inferred by cpDNA sequence combined with those of Tsumura *et al.* (2011)
Figure 2: Phylogenic position of *S. solanica* and *S. assamica* ssp. koordersii as inferred by nuclear PgiC sequence combined with those of Kamiya *et al.* (2005)
3.2. Discussion

Our study showed that the topology of the PgiC gene tree is essentially consistent with the cpDNA tree. Both PgiC and cpDNA-based trees clarified that S. selanica is grouped within Red Meranti and S. assamica ssp. koordersii is within White Meranti.

Cao et al. (2006) and Indrioko et al. (2006) carried out molecular phylogeny of Indonesian Dipterocarpoideae that includes S. selanica into the analysis. These study clearly divided Dipterocarpaceae into two major clades, tribe Dipterocarpeae and Shoreae but interspecific relationship within genus Shorea has not yet been fully identified. There are few studies on phylogeny that specifically included S. assamica and S. selanica into the analysis. Study by Tsumura et al. (2011) using chloroplast sequence data showed that S. assamica (however sub species was not mentioned) was placed near the node of White Meranti clade and the result was congruent with its taxonomical grouping. While S. selanica was not included in the analysis by Tsumura et al. (2011), study by Yulita et al. (2005) showed a slightly different result. S. selanica was the only Shorea species that grouped into Hopea clade based on trnL-trnF nucleotide sequences. Similar result was applied for internal transcribed spacers regions (ITS), in which S. selanica was grouped together with section Richetioides (Shorea Yellow Meranti) and Hopea.

Intraspecific hybridization is not uncommon among dipterocarps. There have been some molecular indications for hybridization and introgressions happened in dipterocarps, for example, study by Kamiya et al. (2005) showed that there was conflicting topologies of phylogenetic trees from nuclear and chloroplast data which suggested the hybrid origin of the monotypic genus Neobalanocarpus (Kamiya et al. 2005). Other study by Ishiyama et al. (2003, 2005) reported the occurrences of atypical DNA sequences, which were distinct from the majority of the sequences in the same species. Introgression was suggested as the cause for such sequences. While Cao et al. (2006) proposed an introgression as the cause for lower expected degrees of genetic differentiation between sympatric populations of S. leprosula and S. parvifolia, more recent study by Kamiya et al. (2011) identified the occurrence of putative hybrid from three closely related Shorea species in section Mutica (S. curtisii, S. leprosula, and S. parvifolia) by examining DNA sequence variations of two nuclear loci (partial GapC and PgiC region) and one chloroplast locus (trnL-trnF region).

Considering the complexity of islands’ formation in Moluccas and their long isolation period without permanent land bridges among each of the islands (de Jong, 1988), the incongruence of phylogenetic position of S. selanica based on the result by Yulita et al. (2005) with their botanical section (Brachypterae, Shorea Red Meranti) has raised concern on more detailed information for its botanical classification. However our present study both inferred from chloroplast sequence data and PgiC nuclear region does not support this result and apparently confirmed S. selanica as the member of Shorea Red Meranti which is fully support its present taxonomical and morphological classification.

4. REFFERENCES


Camera Trapping for Sustainable Management of IUPHHK-HA

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Camera Trapping for Sustainable Management of IUPHHK-HA

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ABSTRACT

Forests managed under IUPHHK-HA (Izin Usaha Pemanfaatan Hasil Hutan Kayu dalam Hutan Alam) cover most of natural forest in Kalimantan. Therefore, balanced management of the economic activity and biodiversity conservation is important to maintain the abundant of regional biodiversity. This paper studies the possibility of using automatic (trap) cameras for monitoring system the biodiversity of ground mammals and birds in the forest concession area. The result shows that the method was able to monitor the mammals and birds. In the future, the trap camera can also be used for monitoring plants and insects in the area for taxonomic identification purposes.

Keywords: Forest, biodiversity, inventory, monitoring, camera trapping

1. INTRODUCTION

Natural lowland forest in Kalimantan is one of the best place that represents Indonesia’s biodiversity. Most of the areas are forest concession area or known as forest area managed under IUPHHK-HA (Izin Usaha Pemanfaatan Hasil Hutan Kayu dalam Hutan Alam). Previously, various legal system such as Environmental Effect Analysis or in Indonesia known as AMDAL (Analisis Mengenai Dampak Lingkungan Hidup), Periodic Forest Inventory or known as IHMB (Inventarisasi Hutan Menyeluruh dan Berkala) and Working Plan or called as RK (Rencana Kerja Usaha Pemanfaatan Hasil Hutan Kayu) have been introduced for the sustainable management of natural forest under IUPHHK. However, practical methods to inventory and monitor the biodiversity of the concessions are still not much developed. The methods are necessary to conserve biodiversity in effectively and efficiently.

A system for inventory and to monitor the biodiversity of ground-dwelling mammals and birds using automatic camera was introduced. This system allows forest management in such logging company to investigate the species composition, estimate relative density of each species, assess the impact of current management on the biodiversity, identify of species valuable to logging impact and specify HCVF (high conservation value forest) in their concession and improve their management system accordingly. This paper studies the use of camera trapping to monitor the biodiversity in Kalimantan’s forest.
2. MATERIALS AND METHODS

2.1 Study Site to Conduct Camera Trapping

Currently, this system has been applied in some neighbouring logging concessions in Sabah and Sarawak, one in Central Kalimantan and one in East Kalimantan (Table 1, Figure 1). All concessions are managed for sustainable production of timber from natural forests and certified as “well managed” forest concession.

Table 1: Studied concession. CL: conventional logging, RIL: Reduced-impact logging

<table>
<thead>
<tr>
<th>Name of concession</th>
<th>Region</th>
<th>Area</th>
<th>Management history</th>
<th>Forest Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deramakot Forest Reserve</td>
<td>Sabah, Malaysia</td>
<td>551 km²</td>
<td>1956-1985 CL</td>
<td>FSC 1997-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995- RIL</td>
<td></td>
</tr>
<tr>
<td>Tangkulap Forest Reserve</td>
<td>Sarawak, Malaysia</td>
<td>276 km²</td>
<td>1970's &amp; 90's CL</td>
<td>FSC 2011-</td>
</tr>
<tr>
<td>Anap-Muput Forest Management Unit</td>
<td>Sarawak, Malaysia</td>
<td>1,068 km²</td>
<td>1977-2004 CL</td>
<td>MTCS 2008-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2005- RIL</td>
<td></td>
</tr>
<tr>
<td>Sari Bumi Kusuma (SBK)</td>
<td>Central Kalimantan</td>
<td>1,476 km²</td>
<td>1978-1998 CL</td>
<td>FSC 2006-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995- RIL + line planting</td>
<td></td>
</tr>
<tr>
<td>Ratah Timber</td>
<td>East Kalimantan</td>
<td>930 km²</td>
<td>1972- CL</td>
<td>FSC 2012-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2012- RIL</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Locations of four studied areas in Kalimantan and positions of camera traps (red points) in each concession. Green: tall forest, light green: young forest (forests after shifting agriculture or natural fire), brown: oil palm plantation.
2.2 Protocol of Camera Trapping

2.2.1 Study design: Random encounter model

Three systems have been developed to evaluate an abundance of animals using camera trap.

1. Capture-recapture (Karanth and Nichols, 1998, Karanth et al., 2006)
   Estimating the abundance from the frequency that same individual captured repeatedly. This method is recommended to indentify animals identified individually using image taken from the camera.

   Estimating the occupancy probability of such kind species in the study area. It also studies the proportion of species inhabit in a study area from the detection probability.

3. Random encounter model (Rowcliffe et al., 2008, Rowcliffe et al., 2013)
   Estimating the number of species in such kind of area from the trapping rate conditioning according to the variance of detected area randomly, by setting multiple cameras. This method allows to monitor some premises that affected by daily movement and distances of the species in stable and high mobility conditions. This method is effective in various habitat and species density.

In this study, random encounter model was adopted to evaluate the impact of current management on the biodiversity and the number of the animals. However, this method was less accurate to identify species numbers, particularly in such condition where the species unconsciously moves within habitats and the number is abundant.

We have adopted the random encounter model because we are interested to evaluate the impact of current management on the diversity and abundance of the animals. Note, by this method, we could not evaluate the abundance of species if the daily moving distance can vary obviously among habitats, especially arboreal species.

2.2.2 Type of camera trap

There are various types of camera designed for trapping the wildlife. One of the camera available was Bushnell Trophy Cam Model 119436, that cost about Rp 1,400,000,- each. One advantage of this camera include its operational system can operate through six months with only four AA lithium batteries that cost about Rp 80,000/set and can record more than 1,000 images on an 8GB SD card. The camera was set as video mode for 10 seconds long.

2.2.3 Camera setting location

Adequate numbers of plots were located at the entire area in purpose of evaluating whole concession area. Camera setting points were determined to represents the various conditions of the area. Generally, more number of setting points in each plot can detect more plots conditions and create smaller differences among plots. Currently, the calculation of adequate setting point number is still in progress, and data mentioned in this study was described according to ten points which have been set (Table 2).
Table 2: Number of plots and cameras setting points in each study area

| Name of concession & Study periods       |
|----------------------------------------|----------------------------------------|
| Deramakot & Tangkulap                  | 2008-2011                               |
| 12-15 points x 29 plots                | (3 points were used at a time and changed the location every 3-5 months) |
| Anap-Muput                            | 2011-2013                               |
| 8 points x 8 plots                     |                                        |
| SBK                                    | 2010-2013                               |
| 10 points x 10 plots                   |                                        |
| Ratah                                  | 2012-2013 (still in progress)           |
| 10 points x 10 plots                   |                                        |

Each plot is forming a circle within 1 km in diameter. Ten points were selected randomly in a plot using statistical software R 3.0.1 and upload the latitude and longitude of the points into Global Positioning System (GPS) which helped the team find the location and set up the camera.

2.2.4 Setting cameras

In typical condition, camera was set standing on a tree (Figure 2), while in sloping area, camera was set up to face the mountain side. Camera recorded area was set within 5 - 10 m² in every setting points. In flat condition, camera was set face downward. Camera was set about 50 – 100 m above ground depending on the topography and covered by tin roof (30 cm x 30 cm) to protect it from rain (Figure 3).

![Figure 2: A camera setting point in SBK (Sg Ritan-03) and an image of a lesser mouse-deer (*Tragulus kanchil*) taken by the camera.](image)

![Figure 3: A camera with a tin roof.](image)
2.2.5 Managing the data

The SD card memory and batteries were replaced every 5-7 months. The data were then recorded in the three EXCEL sheets.

1. Data of setting points (ID of camera, date of setting and remove)
2. Data of camera-working days at each setting point
3. Data of images (Species name, number of individuals, date and time etc.)

Data analysed includes:

1. Mean trapping rate (MTR) of each species in each plot, averaging trapping rates at camera setting points in the plot.
2. Number of species in each plot.

3. RESULTS AND DISCUSSION

3.1 Findings of Camera Trapping

Animal species identified

Animal species identified by camera trapping is presented in Table 3. Surprisingly, there were many endangered and elusive species were detected by the camera traps, such as Hose’s civet (Diplogale hosei) which was recorded in SBK and become the first species recorded by camera in Indonesia (Samejima and Semiadi, 2012). The result indicates the importance of camera trapping in the concession area under IUPHHK-HA to achieve conservation purposes of various species in the tropical rainforest.

It was not only specific and unique species identified, but also common species that recorded in five different concession areas, such as Asian elephant (Elephas maximus) and Malay badger (Mydaus javanensis) which were commonly recorded in Deramakot and Tangkulap points, but not in other concessions. Bornean red muntjac (Muntiacus muntjak) and Masked palm civet (Paguma larvata) were commonly recorded species in Anap-Muput, SBK and Ratah, but not in Deramakot and Tangkulap.
### Table 3: List of species detected in the five concessions in Kalimantan

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Threatened status</th>
<th>Deramakot &amp; Tangkulap</th>
<th>Anap-Muput (Sarawak)</th>
<th>SBK (Kalteng)</th>
<th>Ratah (Kaltim)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Deramakot</td>
<td>Tangkulap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mammal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moonrat</td>
<td>Echinopsorex gymnurus</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pangolin</td>
<td>Manis javanica</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-fronted surili</td>
<td>Presbytis rubicunda</td>
<td>+ + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-tailed macaque</td>
<td>Macaca fascicularis</td>
<td>+ + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pig-tailed macaque</td>
<td>Macaca nemestrina</td>
<td>VU</td>
<td>+ +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muller’s Bornean Gibbon</td>
<td>Hylobates mulleri</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orangutan</td>
<td>Pongo pygmaeus</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common porcupine</td>
<td>Hystrix brachyura</td>
<td>+ + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick-spined porcupine</td>
<td>Thecurus crassispinis</td>
<td>+ + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spotted porcupine</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sun bear</td>
<td>Helarctos malayanus</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow-throated marten</td>
<td>Martes flavigula</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malay weasel</td>
<td>Mustela nudipes</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malay badger</td>
<td>Mydaus javanensis</td>
<td>+ +</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Otter</td>
<td>Aonyx cinerea &amp; Lutra spp.</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malay civet</td>
<td>Viverra tangalunga</td>
<td>+ + + + + +</td>
<td></td>
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</tr>
<tr>
<td>Otter</td>
<td>Cynocephalus bennetti</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binturong</td>
<td>Arctictis binturong</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small-toothed palm civet</td>
<td>Arctogalidia trivirgata</td>
<td>+ + +</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Masked palm civet</td>
<td>Paguma larvata</td>
<td>+ + + + + +</td>
<td></td>
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<tr>
<td>Common palm civet</td>
<td>Paradoxura hermaproditus</td>
<td>+ + + + + +</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Horse’s civet</td>
<td>Diplogale hosei</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
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<tr>
<td>Banded civet</td>
<td>Hemigalus derbianus</td>
<td>VU</td>
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<tr>
<td>Banded linsang</td>
<td>Pseudois nasicornis</td>
<td>+ + + + + +</td>
<td></td>
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<td></td>
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<tr>
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<td>Herpestes semitorquatus</td>
<td>+ + + + + +</td>
<td></td>
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<tr>
<td>Short-tailed mongoose</td>
<td>Herpestes brachyrurus</td>
<td>+ + + + + +</td>
<td></td>
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</tr>
<tr>
<td>Clouded leopard</td>
<td>Neofelis dardii</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
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<tr>
<td>Marbled cat</td>
<td>Paraphelis marmorata</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
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<td></td>
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<tr>
<td>Flat-headed cat</td>
<td>Prionailurus planiceps</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
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<tr>
<td>Leopard cat</td>
<td>Prionailurus bengalenis</td>
<td>+ + + + +</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Bay cat</td>
<td>Catopuma badia</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian elephant</td>
<td>Elephas maximus</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearded pig</td>
<td>Sus barbatus</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser mouse-deer</td>
<td>Tragulus kanchil</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater mouse-deer</td>
<td>Tragulus napu</td>
<td>+ + + + + +</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Bornean red muntjac</td>
<td>Muntiacus muntjak</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bornean yellow muntjac</td>
<td>Muntiacus atherodes</td>
<td>+ + + + + +</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sambar deer</td>
<td>Cervus unicolor</td>
<td>VU</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tembadau</td>
<td>Bos javanicus</td>
<td>EN</td>
<td>+ + +</td>
<td>+ + +</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Ground birds              |                 |                   |                       |                      |               |               |
| Crested fireback          | Lophura ignita  | + +               | + + +                  | + + +               |               |               |
| Crestless fireback        | Lophura erythroptala | VU           | + + +                  | + + +               |               |               |
| Buhlere’s pheasant        | Lophura bulkeni | VU                | + + +                  | + + +               |               |               |
| Crested partridge         | Rhabdornis rouloul | + + + + + + |                       |                      |               |               |
| Bornean peacock pheasant  | Polyplectron schlegelii | EN  | + + + + + +            |                      |               |               |
| Great argus               | Argusianus argus | + + + + + +       |                       |                      |               |               |
| Chestnut-necklace partridge | Arborophila charltoni | + + + + + + |                       |                      |               |               |

| Number of species (mammals & ground birds) | 39 | 35 | 34 | 41 | 33 |


### 3.2 Evaluation of Impact of Current Forest Management

Comparing the MTRs and similarity of the species composition among plots, evaluation was carried out in the impact of current management to the diversity of the ground-dwelling mammals and birds. Figure 4 shows that the location of 8 plots in Anap-Muput, Sarawak and MTRs of all species at each plot shows that species were low at C24, while there was no significant species number differences at Keranga forest (heath forest) before Reduced impact logging (C04 & C16) and after logging (C06-C12).

In this condition, current management in this concession should be considerably avoid harming the mammals and ground birds. Similar pattern was also shown in Deramakot (Samejima et al., 2017).
On the other hand, species richness and MTRs of many species in Tangkulap, next to Deramakot, were lower than Deramakot (Imai et al., 2009, Samejima et al., 2012a). Repeated conventional logging conducted in Tangkulap in 1990’s may be one factor causing the degradation of the species composition.

3.3 Identification of Species Vulnerable to Logging Impact

For sustainable forest management, identifying the recorded species was able to make easier assess to the biodiversity status. For example, Figure 5 shows the distributions of MTRs of Sambar deer and Bornean yellow muntjac in Deramakot and Tangkulap. Data analysis shows that MTR of Sambar deer was not significantly different between concessions, MTR of Bornean yellow muntjacs in Tangkulap were lower than that of Deramakot. It shows that Sambar deer is robust to the forest degradation by conventional logging, while Bornean yellow muntjac is more sensitive by the impact. Therefore, Bornean yellow muntjac can be a good indicator of the impact degradation to biodiversity.

Figure 5: MTRs of Bornean yellow muntjac and sambar deer in Deramakot and Tangkulap. The size of red circle shows the MTRs at each plot.
3.4 Detecting HCVF in the Concession

In general, High Conservation Value Forest (HCVF) can be analysed based on the camera trap data in the concessions. In SBK (10 plots), species recorded includes orang utan and Hose’s civet only in the Bukit Selangit plot (Figure 6). This area was then set as HCVF accordingly.

Figure 6: Plot Bukit Selangit (“B”) in SBK is far from national parks and outside the conservation areas in the concession. However, the plot has a unique species composition, Orangutan and Hose’s civet were recorded only in this plot.

4. CONCLUSIONS

Camera trapping is one effective way to monitor and analysis of ground mammals and birds in a concession area under IUPHHK-HA. This method will improve the effect of biodiversity conservation through sustainable management of logging concessions and enable to conserve the regional rich biodiversity of Tropical Rain Forest such as Kalimantan. Mammals and birds are only part of the rich biodiversity of the natural tropical rainforest. Large scale inventory and monitoring systems for other taxonomic groups, such as plants and insects also need to be developed in future studies.

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5. REFERENCES


Conservation of *Pinus merkusii* Strain Kerinci by Developing *Ex-Situ* Conservation Plot

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ABSTRACT

*Pinus merkusii* strain Kerinci is one of pine species that grows naturally in south across the equator until 2°S. By the time, *P. merkusii* strain Kerinci became scarce. The scarcity are considered to: the low natural regeneration ability, land use forest conversion by the community with illegal logging, and reduced genetic of *P. merkusii* strain Kerinci by *P. merkusii* strain Aceh plantation around it's natural habitat. The aim of this research was to conserve *P. merkusii* strain Kerinci from scarce by developing ex-situ conservation plot. Genetic material was explore in their natural habits in Bukit Tapan, Pungut mudik, and Bukit Terbakar, Kerinci Regency, Jambi Province and then cultivate in nursery of Balai Penelitian Kehutanan Aek Nauli. Ex-situ conservation plots were develop in Sipiso-piso, Tanah Karo Regency and Kawasan Hutan Dengan Tujuan Khusus (KHDTK, forest area for specific purpose) Aek Nauli, Simalungun Regency, both of them in North Sumatra Province. Result showed that live percentage of *P. merkusii* strain Kerinci after plantation was quite high at 96,37%. With intensif maintenance, ex-situ conservation plot could be succeed and *P. merkusii* strain Kerinci scarcity could be overcome.

Keywords: *Pinus merkusii*, strain Kerinci, ex-situ conservation

1. INTRODUCTION

*Pinus merkusii* is an Indonesia native species that found on Sumatra island. In Sumatra, stands of *P. merkusii* divided into three strains namely: Aceh, Tapanuli, and Kerinci. *P. merkusii* strain Kerinci is one of pine species that grows naturally in south across the equator until 2°S. *P. merkusii* trees are an important type of timber carpentry and wood fiber which produce non-timber forest products such as Gum Rosin. Gum Rosin is an important ingredient for making batik which is the result of Indonesian culture (Edy, 2011).

Recently, the status of *P. merkusii* strain Kerinci particularly is scarce. CITES data showed that *P. merkusii* strain Kerinci (commonly known in local language as “Sigi”) on the verge of extinction. This is due to its amount in natural stands have been substantially reduced. Many things that are considered to be the causes of the scarcity are: 1) the low natural regeneration ability, 2) land use forest conversion by the community with illegal logging, and 3) reduced genetic of *P. merkusii* strain Kerinci by *P. merkusii* strain Aceh plantation around it's natural habitat (Edy, 2012).

Considering the importance of the pine as a natural biodiversity and economic benefits, it needs to attempt preserving and purity this species. Some of the way is by doing ex-situ conservation of *P. merkusii* strain Kerinci.

2. DESCRIPTION *Pinus merkusii* STRAIN KERINCI

Scientific classification of *Pinus merkusii* was describe as follow:

Division: Spermatophyta
Sub Division: Gymnosperms
Class: Coniferae
Order: Pinales
Family: Pinaceae
Genus: Pinus
Species: *Pinus merkusii* Jungh. Et de Vriese.

*Pinus* commonly known as Tusam (Tapanuli) or Sigi (Kerinci) is a large tree with a straight and cylindrical bole. Old trees may reach 45 m in height and 140 cm in diameter (Hidayat & Hansen, 2002). *Pinus merkusii* can grow on poor or acid soils and the climate with minimal rainfall (dry climate), but the best perform on climate B (according to Schmidt and Ferguson classification). Required rainfall is 1500 mm/year and will grow well in areas that receive rain throughout the year. It is optimally at moderate altitude mostly 400-1500 m, but also found at elevation of 800-2000 m. The required temperature ranges between 17-27°C. Can not grow well in the shade (Darsidi, 1983).

*P. merkusii* strain Kerinci have differences with strain Aceh and Tapanuli. Strain Kerinci have thin bark with a straighter and cylindrical rods. Stems grooves more shallow and whiter (Armizon in Hendi, et. al., 2006). Differences between strains Kerinci with other strains covers the color of the leaves, bark, sap productivity, wood grain appearance and branching tree. Tapanuli pine has a relatively straight trunk, branches and canopy are more slender, thin and ungrooved bark and leaf color more younger. Kerinci pine bark is relatively smooth and ungrooved than Tapanuli (Harahap and Aswandi, 2006).

3. *Pinus merkusii* STRAIN KERINCI IN NATURAL HABITAT

Kerinci pine spread naturally in three locations: Bukit Tapan, Pungut Mudik and Bukit Terbakar. This location is a mountainous region with altitude above 900 m. According Istomo, et. al. (2000), Kerinci pine growth is influenced by soil type and soil properties, elevation from sea level and slope.

Edy (2011) showed that *P. merkusii* strain Kerinci spread in the mountain forests (900 - 1465 m) in Jambi Kerinci regency. Distribution of Kerinci pine tend to be small clustered or solitary with natural regeneration potential is very low. Pine stands in Bukit Tapan grow above 900 meters with slopes up to 85%. In this area, *P. merkusii* strain Kerinci grows naturally in red-yellow podzolic soil and ground podsol, latosols and litosol, the climate type A and B with an average rain fall per year are 1945-2027 mm (Cooling, 1968).

Planting Aceh pine close to natural populations of strain Kerinci in Bukit Tapan would threaten the purity of Kerinci pine. *P. merkusii* strain Kerinci purity can be contaminated by strains Aceh through cross-pollination between the two populations. *P. merkusii* strains Aceh are now producing young trees that have started to produce cones. If no gradual elimination of strains Aceh is fearedon the next time the population will fused and cross-pollination occurs.

Observations Kerinci pine cone production in Pungut Mudik and Bukit Terbakar showed very low yield, that is only an average 22.4 cones per tree with the number of seeds per cone is 8.8 seed, and 21% cone does not have seeds. Seed germination test results also showed very low germination percentage, only 0.4%. (Edy, 2011).
Suhaendi (2005) also stated that the amount of natural seedlings Kerinci pine found in the forests of Bukit Tapan very little, just 60 seedlings, while in Pungut Mudik not found seedling sat all. Natural seedling were found far from the position of the parent tree. Absence of natural seedlings in Pungut Mudik caused by seed that falls to the forest floor is very rare because of the wind and if they germinate, it soon die due to heavy shade, so that no direct light is obtained.

The results of the variation through isoenzyme analysis conducted by Munawar and Na’iem (2003) showed that the variation of Kerinci pine least than Tapanuli and Aceh. The same thing has been done by Siregar and Hattemer (2004) which showed the variation of strain Kerinci pine was not found than Aceh strain and stand from Java. This proving that the variation in natural populations in Kerinci is very low due to natural population in Kerinci was fragmented by a collection of individuals in the amount and extend of that narrow. The result is a backward selection and relatives mating occurs.

4. METHODOLOGY

4.1 Obtaining Seedling

Seedlings of *P. merkusii* strain Kerinci is taken from its natural habitat in Bukit Tapan and Pungut Mudik. The choice of location is due to easier access and a number of stands that are still abundant. So, the natural seedlings obtained will be mainly. Retrieval technique of natural seedlings is through a uprooted system. Revocation is done carefully by lifting soil around the seedling so the roots are not damaged. Pine seedling were obtained and collected temporarily planted in groups in polybags with media topsoil from below stands. The number of seedlings in one polybag adjusted to the size and magnitude of polybags. This is to facilitate the transportation on the field. Seedlings then were placed in the shade, avoid direct sunlight and protected from wilting and dry by watering.

4.2 Seedling Preparation

Natural weaning is done on the nursery of Forestry Research Institute of Aek Nauli in the shaded trees, ie below the Pinus stands. Natural seedling planted in polybags soon. Polybag placed in beds be covered weaning plastic to keep the humidity remains high. High humidity in the containment is marked with dots of water/dew attached to the plastic lid. Each seed is labeled according the source of origin. Natural seedling weaning using plastic lid take place for approximately two months. In the weaning period, when the lid looks dry no dew points that attach to the plastic indicating humidity inside the lid is reduced, hence watering. After two months on containment, subsequently opened the lid and seeds left in the weaning plot approximately one month for the process of adaptation by keep doing regular watering as needed. Number of seedlings that die or life was recorded to calculate the survival of the seedlings during the weaning process. Subsequently seedlings transferred to the nursery with shadingnet for maintenance and acclimatization process until seedlings ready for planting. Maintenance was done by watering seedlings every day or as needed and manure application. Two months before planted, shadingnet was opened to make seedlings get full sun exposure (process of hardening off) until the seedlings ready to be planted in the planting location without experiencing stress due to changes in environmental conditions.

4.3 Site Selection

Selection of plot site outside of their natural habitat were based on climatic conditions, site and altitude approaching the native range conditions. The location of conservation plot selected at the Sipisopiso, administratively located in Kecamatan Merek, Tanah Karo, North Sumatra. Sipisopiso climate type B with an average number of rainy days per year 133 days and rainfall 1.550 mm (Ali,
Type of soil is Podsolic to Podsolic Brown Grey with parent materials igneous rocks wry. Soil pH ranged from 4.5 to 6.5 (Sukmana, 2009). Planting site is located at altitude of 1.488-1.494 m with a slope about 12%. Recording temperatures during the day around 29.20°C - 31.75°C with maximum humidity 56.90% and 53.30% for minimum.

4.4 Plot Development

The completion of the cultivation is done two months before the seedlings were planted by clearing grassland and shrubs. Spraying with herbicides was done on grass and shrubs which grow return a few weeks after clearing. Marker attached in all planting hole and label wereplugged on every marker appropriate plants code. Planting hole made with a standard width of 30 x 30 and a depth of 25 cm and given 0.5 kg compost per planting hole. Spacing used was 5 x 7 m. Planting is done at the time of the rainy season which is marked by a continuous rain.

4.5 Plot Maintenance

Maintenance of the plants done by making plate around the plants and interweaving die seedling in the first month of planting. Further routine maintenance is done every three months by making plate around the plants and clearing bushes that grows in areal plot. The measurements did in order to see plants growth continuously with high parameter until 12 months after planting.

5. RESULTS AND DISCUSSION

5.1 Obtaining Seedling *Pinus merkusii* Strain Kerinci

The seed of *P. merkusii* strain Kerinci in Bukit Tapan and Pungut Mudik was taken from natural seedling. Retrieval technique of natural seedlings was done carefully by lifting soil around the seedling so the roots are not damaged. The seeds have a high diversity and commonly found in open areas. It’s consistent with the results of the study Edy (2012) in which the natural seedling of *P. merkusii* as seen in strain Aceh and strain Tapanuli, grown in open area without vegetation underneath plants, like former soil erosion.

5.2 Seedling Preparation of *Pinus merkusii* Strain Kerinci

The growth percentage of seeds from natural seedling that weaned with covered plastic from several sample were between 70-85% in nursery. Natural seedling that weaned using plastic lid is a simple method to create plant seeds from natural seedling.

5.3 Plot development of *Pinus merkusii* strain Kerinci Ex situ Conservation

To improve the growth rate percentage and reduce the risk of failure (death of plants), planting was done when it has entered the rainy season in November. Measurements and observations of plants at the age of 6 months after planting showed that the average survival rate reached 96.37% (Table 1).

<table>
<thead>
<tr>
<th>Seed origin</th>
<th>Average height 1 map*</th>
<th>The average height of 6 map</th>
<th>Average Growth</th>
<th>Percent survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bukit Tapan</td>
<td>28, 63 cm</td>
<td>52.07 cm</td>
<td>22.68</td>
<td>93%</td>
</tr>
<tr>
<td>Pungut Mudik</td>
<td>23, 87 cm</td>
<td>50.47 cm</td>
<td>26.60</td>
<td>100%</td>
</tr>
</tbody>
</table>

*map : month after planting
Preparation of *P. merkusii* strain kerinci seed from natural seedling is one of the ways to obtain material for conservation ex situ. However, according to Suhaendi (2006), conservation ex situ using natural seedling has never been done, either by society / people and various forestry institution in Indonesia. This may be due to the difficulty of obtaining natural seedling in their natural habitat like in Bukit Tapan and Pungut Mudik or because the failure at preparing seedlings in nursery. The percent survival reached 96.37% at the age of 6 months after planting indicates that the *P. merkusii* strain Kerinci can adapted in Sipisopiso.

The planting sites have the same altitude (above sea level) with the natural distribution of *P. merkusii* strain Kerinci in TNKS and surrounding areas. Both the climate and soil type at the planting site have similarity with a natural distribution *P. merkusii* strain Kerinci.

### 5.4 Plot Maintenance

In the first month after planting, water availability is important for plant growth. Therefore, for the successful growing of plants, the planting should be done during the rainy season. Plant maintenance in the third months has been intensified since the growth of weeds, especially *Glyceria linearis* and *Imperata cylindrica* L.Beauv. Then periodically plot maintenance did every 3 months including weeding.

### 6. CONCLUSIONS AND RECOMMENDATION

#### 6.1. Conclusions

1. The success of *P. merkusii* strain Kerinci seedlings growing in nursery by weaned using plastic lid reaches 85%.

2. Until the age of six months after planting, *P. merkusii* strain Kerinci in Sipisopiso adapt pretty well. It's marked on the survival rate is quite high, reaching 96.37% and an average height growth 22.68 cm of Bukit Tapan and 26.60 cm of Pungut Mudik.

#### 6.2. Recommendation

Considering the need for routine maintenance a young plant conditions and climatic factors were very hot in the dry season. So that needs to be done undertakings of fire prevention with the creation of firebreaks and reduce the amount of material that could be a bush fire.

### ACKNOWLEDGEMENT

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### 7. REFERENCES


Molecular Characterization of Gene Encoding Carboxymethyl Cellulase from  
*Aspergillus niger* IPB1  

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ABSTRACT

Since cellulose is the most abundant biomass in nature, an enzyme that capable of degrading cellulose, known as cellulase, has been receiving considerable attention in industrial, environmental and agricultural. In the future, this enzyme will get more attention due to increase on issue of bioethanol production from cellulosic material. There are three types of cellulase enzyme, namely exoglucanase, endoglucanase and glucosidase. Molecular approach is one of the best tools to increase enzyme activity in order to meet the needs of the world enzyme market. In this study, gene encoding endoglucanase or carboxymethyl cellulase (CMCase), known as *egl*A was characterized. This gene consists of 720 bp nucleotides and encoded 239 amino acids. Based on amino acids deduction, this enzyme did not have a carbohydrate binding module (CBM). Based on the comparison of homologous structures with the known structure and catalytic residues that have been defined, the residues that play a role in the catalytic function of this enzyme, which were predicted as a nucleophile Glu116 and Glu204, were predicted as a proton donor. While glycosylation site predicted binding sites are composed of Trp residues (positions 22, 49, 51, 85, 120, 144), Tyr (61, 98, 115) and Phe (163, 179).

Keywords: *Aspergillus niger* IPB1, CMCase, gene

1. INTRODUCTION

Cellulase is one of a group of enzymes produced by microorganisms that play a role in the degradation of plant cell wall material. This enzyme is belonging to the glycoside hydrolases (GH) family. Cellulase enzymes hydrolyze cellulose with a synergetic action by cleaving bonds of β-1,4-D-glycosidic to produce oligosaccharides and glucose. Besides a role in the hydrolysis of cellulose, cellulase enzymes are used also for various purposes in industries, such as pulp and paper industry for deinking and fiber modification; textile industry for cotton softening and denim finishing stage; industrial detergent for color care, cleaning and anti deposition, and food industry as a food tenderizer (Zhang et al., 2006). Together with hemicellulase, cellulase accounts for approximately 20% of the total world enzyme market (Coral et al., 2002). Future potential market of cellulase is predicted to increase significantly with the increase of issue of the conversion of cellulosic materials into ethanol.

Cellulase enzymes are classified into three types, namely endoglucanase (endo-β-1,4-glucanase, EC 3.2.1.4), cellobiohydrolase or exoglucanase (exo-β-1,4-glucanase, EC 3.2.1.91) and glucosidase (β-D-glucoside glucohydrolase, EC 3.2.1.21) (Lynd et al., 2002). Hydrolysis of cellulose into glucose is working in synergetic manner of the three groups of these enzymes. Endoglucanase hydrolyzes internal bonds of cellulose to produce new chain ends, exoglucanase hydrolyzes new chain ends of cellulose to produce cellobiose or glucose, and glucosidase hydrolyzes cellobiose into glucose. Endoglucanase hydrolyze cellulose randomly so that degradation of cellulose running fast.
Some microorganisms are known to have an ability to produce cellulase. However, fungi are known to be the main cellulase producing microorganisms. Some group of filamentous fungi such as Aspergillus and Trichoderma cellulase is an efficient producer (Gielkens et al., 1999) and the most current commercial production of cellulase enzymes in the world produced by these two groups of fungi (Kirk et al., 2002).

Cellulase activity of \textit{A. niger} has been studied and characterized (Onsori et al., 2004; Coral et al., 2002; Hurst 1977), including several genes that encoding cellulase. Cellulolytic system on \textit{A. niger} consists of three genes that encoding endoglucanase: eg\textsubscript{A}, eg\textsubscript{B} (van Peij 1998) and eg\textsubscript{C} (Hasper et al., 2002) and two genes that encoding cellobiohydrolase: cbh\textsubscript{A} and cbh\textsubscript{B} (Gielkens 1999). However, study of CMCase activity and genetic information of local strains of Indonesia is still less available. This paper presented the results of the study aiming at characterizing the structure of the gene encoding endoglucanase from a local isolates of \textit{A. niger}.

2. MATERIALS AND METHODS

Nucleotide sequence was analyzed from the gene encoding endoglucanase of \textit{A. niger} IPB1, an Indonesian local isolate. Nucleotide sequence used was isolated from eg\textsubscript{A} cDNA fragment that were sequenced using the ABI Prism Model 3100 version 3.7 DNA sequencer. Endoglucanase gene nucleotide sequences were then analyzed using a program available. Deduced amino acid was accomplished using the Translate Tools, domain analysis performed using Pfscan program, multiple sequence alignment performed with the program Tree-based Consistency Objective Function For alignment Evaluation (T-COFFEE).

3. RESULTS AND DISCUSSION

Egl\textsubscript{A} gene sequence of \textit{A. niger} is presented in Figure 1. This gene consists of 720 bp encoding 239 amino acids.

![EglA nucleotide sequence](image)

Figure 1: eg\textsubscript{A} nucleotide sequence \textit{A. niger} IPB1 and amino acid deduction

Egl\textsubscript{A} domain analysis was performed using the program Pfscan based Pfam database. Egl\textsubscript{A} have a catalytic domain belonging to glycoside hydrolase family 12 (GH12) at amino acid position 82 to amino
acid 239 (Figure 2). Architecture EglA of A. niger is the same as the architecture of some other GH12 family members, such as Cel12A T. reesei and Cel12A B. Licheniformis. This type of architecture containing only the catalytic domain and contains no carbohydrate binding moduls (CBM).

In general, groups of glycoside hydrolase composed of two major domains, the catalytic domain and the carbohydrate binding moduls (CBM) which are connected by a proline-rich linker (Figure 3). The position of the catalytic domain and CBM domains can be found on the C-terminal and N-terminal. This position does not determine the specificity of an enzyme (Gilkes et al., 1991). The role of CBM domain on the enzyme is still unclear. However, Hashimoto (2006) reported a major role of CBM is to improve the efficiency of the catalytic functions of enzymes carboxydrase although the mechanism is not yet clear.

**Figure 2: EglA domain comparison of various organisms based database pfam**

- **A. niger (Glyco hydro 12: 82-239)**

- **T. reesei (Glyco hydro 12: 81-234)**

- **S. lividans (Glyco hydro 12: 111-261; CBM 2: 279-378)**

- **B. licheniformis (Glyco hydro 12: 104-261)**
Figure 3: General domain of cellulose, which are consisting the catalytic domain and CBM regions connected by connecting (linker)

GH12 is one of the glycoside hydrolase family with endoglucanase activity and xyloglukan hydrolase. The catalysis mechanism is retaining mechanism with glutamatic (Glu) as a nucleophiles bases and proton donor. Recently GH12 family has around 151 members with 7 different architectures. Most members of GH12 have no CBM domain architecture. While the architecture with the combination between the catalytic domain and CBM domains, such as the Cel2B of \textit{S. lividans}, is only a little.

Based on the comparison of homologous structures with other endoglucanase structures already known, the residues that play a role in the catalytic function of \textit{Egl}A of \textit{A. niger} IPB1 and the substrate binding can be deduced (Figure 4). Glu116 is predicted to act as a nucleophile and Glu204 is predicted to act as a proton donor. In the GH12 family, the nucleophile position was closed to two highly conserved residues, Asp99 and Met118 (Sandgreen et al., 2003; Zechel et al., 1998).

Glycosyl binding site was predicted to compose several residues with aromatic side chains, such as Trp, Tyr and Phe (Sandgreen et al., 2003). Refers to several residues involved in substrate binding of GH12 family (Goegedebuur et al., 2002), Trp residues (positions 22, 49, 51, 85, 120, 144), Tyr (61, 98, 115) and Phe (163, 179) on \textit{A. niger} IPB1 was predicted to plays a role as glycosylation binding substrate.

Figure 4: Alignment of amino acid sequences of four enzymes GH 12. The position of the proton donor and nucleophile residues was indicated by black and white arrows, respectively
4. CONCLUSION

Characterization results showed EglA of *A. niger* IPB1 is a protein that includes the family members of glycoside hydrolase family 12 with residues Glu116 and Glu 204 as the nucleophile and proton donor respectively.

5. REFERENCES


The Diversity of Ants in Different Ecosystem Types in Jambi

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The Diversity of Ants in Different Ecosystem Types in Jambi

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ABSTRACT

One of the most dominant insects found in Tropical Forest Ecosystems is ants (family Formicidae). This insect makes large forming colonies and occupies an important position in the food web as predators and scavengers. They also have a role in controlling the population of phytophagous insect. However, the relationship between forest and ant species diversity is not yet definitely recognized. The objective of this study was to determine the diversity and community structure of Ants found in different ecosystem types in Jambi. Ants was collected using a pitfall trap from four ecosystem types, namely secondary forest, jungle rubber, rubber plantation and oil palm plantation in Jambi. The Ants were identified based on their morphospecies up to subfamily. Result of this study shows that there were five subfamilies found in these ecosystem types, i.e. Dolichodorinae, Formicinae, Myrmicinae, Ponerinae, and Pseudomyrmicinae. Among four ecosystems, secondary forest provide the highest richness species and rubber plantation provide the greatest diversity species and also evenness species of ants. The most dominant subfamily found in each ecosystem type was Formicinae. Ants found in the jungle rubber were the most abundant compare to other ecosystem types, even in the secondary forest. It can be estimated that the abundance of Formicinae subfamily was higher in the ecosystem type consisting of mixed species (combination of monoculture plantation and forest), where the abundance of plants species may be still high. They great abundance was supported by the characteristic of Formicinae, that is easily adapted to other ecosystems changes, especially that found in Jambi.

Keywords: Ants, secondary forest, jungle rubber, rubber plantation, oil palm plantation

1. INTRODUCTION

Ants, family of Formicidae, were found most dominated insect that lived in Tropical Forest Ecosystems. Ants are collectively classified in a single family, the Formicidae, in the order Hymenoptera Hölldobler and Wilson (1990) in Torhorte et al.(2010). In the world, there are 23 subfamilies of ants which comprised of 287 genera and approximately 12,000 described species, with a likely much larger number of species, yet to be described Bolton et al. (2006) in Torhorte et al. (2010). This insect makes large forming colonies and occupies an important position in the food web as predators and scavengers.

Ants have a role in controlling the population of phytophagous insect. Wang et al. (2000) described that ant societies are susceptible to environmental disturbances by being tied to the same location. They are dependent on structure, moisture and temperature of the soil, as well as the structure of the vegetation and the populations of other arthropods. Because of their great abundance, functional importance, and the complex interactions they have with the rest of the ecosystem, ants are often used as bio-indicators in environmental assessment programs. However, the relationship between forest and ant species diversity is not yet definitely
recognized. The objective of this study was to determine the diversity and community structure of Formicidae found in different ecosystem types.

2. METHODS

2.1 Sampling Method

In each ecosystem type (oil palm plantation, rubber plantation, jungle rubber and secondary forest), a permanent plot of 1m × 1m was established as a sampling area. Every quadrates of each plot was dug at the center where a plastic (pitfall trap) was placed in each hole with the lip of the trap level with the soil surface. Detergent solution (to gave ants a death blow) was poured into the trap to a depth of about 2 cm. Samples were collected after 3 days and taken to the laboratory for sorting. The sample collection was done twice as replication.

2.2 Ant Collection and Identification

Collection of the ants was preserved in 75% alcohol and subsequently taken back to the laboratory for classification. Identification of ants to sub-family was based on the keys by Bolton (1994) and also compared with the reference collections at the Forest Entomology Laboratory, Department of Silviculture, Bogor Agricultural University (IPB).

2.3 Data Analysis

The Shannon-Wiener’s diversity index was used to calculate the diversity of ants collected. The Shannon Wiener index has two characters, which are: (1) H’ =0 if and only if available one samples deep types, and (2) H’ maximums only when all types (total in community types) are represented by total same individual, one that constitutes perfect profusion distribution (Ludwig and Reynolds 1988). The formula of the Shannon-Wiener’s diversity index used is presented below:

\[
H' = - \sum_{i=1}^{s} p_i \ln p_i \ ; \ p_i = \frac{n_i}{N}
\]

Where,

\( H' \) = Species diversity index  
\( n_i \) = Number of individuals of species\( i \)  
\( N \) = Total number of samples  
\( p_i \) = Proportion of total sample represented by species \( i \)

The species richness was calculated with Margalef Index formula (1958) pointed in (Ludwig and Reynolds 1988) as follows:

\[
R = \frac{S - 1}{\ln (N)}
\]

Where,

\( R \) = Species richness  
\( S \) = Number of species  
\( N \) = Number of individuals
The evenness species index \((E)\) was also calculated to determine the equal abundance of ants in each study site (Ludwig & Reynolds 1988). \(E\)'s point ranging from 0 to 1. \(E\)'s point that approaches 0 means that a type becomes dominant in community. If \(E\)'s point approaches 1, it means that all types have to increase the abundance close to resemblance type. The formula as is as follows:

\[
E = \frac{H'}{\ln (S)}
\]

Where,

- \(E\) = Evenness index
- \(H'\) = Observed of species diversity index
- \(S\) = Number of species

3. RESULTS AND DISCUSSION

The ant of four ecosystem types, namely Oil Palm Plantation, Rubber Plantation, Jungle Rubber and Secondary Forest in Jambi consist of five subfamilies. The five subfamilies are Dolichodorinae, Formicinae, Myrmicinae, Ponerinae, and Pseudomyrmicinae. Ants collection of four ecosystem types were identified into morphospecies, follow as Dolichodorinae into 5 morphospecies, Formicinae into 17 morphospecies, Myrmicinae into 13 morphospecies, Ponerinae into 14 morphospecies and Pseudomyrmicinae identified into 8 morphospecies. Based on the number of morphospecies (Figure 1), Secondary Forest contributed to present much morphospecies (44 morphospecies) more than other ecosystem types, where the number of plant species was higher.

![Figure 1: Number of morphospecies on four ecosystem types](image)

There are different dominance subfamily that based of ant were collected from each ecosystem types. The number of individu (Figure 2.) of Secondary Forest and Oil Palm Plantation were good for supplying subfamily of Myrmicinae each of 455 individual. Other ecosystem types; Jungle-Rubber and Rubber Plantation keep a suitable habitat of Formicinae, each of 435 individual and 1565 individual.
The diversity of ants (Figure 3.) from Rubber Plantation bigger than Secondary Forest as it individual number of species in Secondary Forest not all distributed, contrast with Gadagkar et al., (1994) saying that there are significant positive correlation between ant species diversity and plant species diversity.

On the other hand, Secondary Forest has a great richness of species than other ecosystem types (Figure 4). Amount of ants was big as 1384 individual as the various type consist of 44 sub-species, where based on number of species in Figure 1.
Figure 4: Richness index of ants in four ecosystem types

In figure 5, show all of ecosystem types was contributed to present ants community in a shape of approximately equal, showed from the evenness spesies index showed number between 0,5 – 0,75. Even the ecosystems with monoculture plant giving same contribution to the evenness species index like the other mixed crop system.

Figure 5: Evenness index of ants in four ecosystem types

4. CONCLUSIONS

This study showed there are five subfamilies of ants in fragmented ecosystems, such as Dolichodorinae, Formicinae, Myrmicinae, Ponerinae, and Pseudomyrmicinae. Formicinae, the most dominant subfamily found fragmented ecosystems, shows that formicinae most adapted to exchangeable condition other than the other subfamily. If there more present more fragmented ecosystems it can effected to species diversity that live on those ecosystem. Hence the decision to manage an ecosystem need to pay attention to the sustainability of life-related types in it, especially to the biodiversity existing.

5. REFERENCES


Gained Experience Through Direct Seeding of Several Tree Species in Degraded Land in West Java, Indonesia

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ABSTRACT

Rehabilitation of degraded land is usually conducted by planting seedlings but direct seeding may be an alternative way of accelerating forest recovery and succession processes. This study investigated the effects of various seed and sowing treatments on the early establishment and growth of direct seeding of forest tree species in Parung Panjang, Bogor, West Java, Indonesia. This research used seven forest tree species, i.e. Acacia mangium, A. crassicarpa, A. aulacocarpa, Intsia bijuga, Macoposis emenii, Melia azedarach, and Gmelina arborea. Seeds from each species were sowed by using randomized completely design with 2 factors, i.e. site condition and sowing treatment. The seed was sowed on under tree stands and in open area in the way of: (1) the untreated seeds were sown on the site–soil surface, which had been left uncleared, (2) the untreated seeds were sown on the site–soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened, (3) the untreated seeds were sown on the site–soil surface which had been cleared and loosened, (4) the treated seeds, afterwards sown on the site–soil surface, which had been cleared and loosened, and (5) the treated seeds, afterwards sown on the site–soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened. The results showed that A. crassicarpa, A. mangium, A. aulacocarpa, M. eminii, and G. arborea were potential for direct seeding implementation. The Acacias species were better in the open areas, while the other species were better under tree stands. Acacia as small seeded species could grow quickly, and the seedling growth was found to be negative affected by the growth of weeds, and M. azedarach and I. bijuga as large seeded species were often rather slow to grow so they relatively could not be competed with weeds. The best germination percentage and seedling growth were achieved by the implementation of seed treatment and followed by seed sowing on the site surface which had been holed with 2 – 3 cm depth which had been cleared and loosened as well as with seed sowing. Direct seeding could be a promising method for tree planting, but the species characteristics to be used, the circumstance manipulation and the appropriate timing of sowing will vary with situations.

Keywords : degraded land, direct seeding, forest tree species, rehabilitation, seed sowing.

1. INTRODUCTION

Rate of Indonesia’s tropical rain forest degradation is not able to be equalized by its reforestation through planting activities or natural regenerations. This condition was affected on increasing of degraded lands. According to Ministry of Forestry (2009), critical lands were reached ±77.8 million ha with rate of degradation about 1.08 million ha per year. With continuing rates of deforestation and increasing land degradation in Indonesia’s tropical rainforest regions, the reforestation activities should be conducted intensively.

The predominant method used to restore degraded tropical lands is to plant nursery-raised tree seedlings. Although this can be an effective technique for quickly establishing forest cover (Wishnie et al., 2007; Holl et al., 2010), there can be quite costly and labor intensive (Engel and Parrottta, 2001; Zahawi and Holl, 2009). The development of low cost methods for forest
rehabilitation that can be applied on a broad scale have become of increasing interest. One potential alternative is to use direct seeding as it has few requirements for labor and greater resource efficiency than other tree establishment methods (Lamb and Gilmour, 2003).

Although direct seeding has not been widely adopted in forestry practice, it has been successfully used for establishment of some tropical and subtropical tree crops such as Acacia, Anacardium occidentale, Gmelina arborea, and Pinus sp. (Doust et al., 2006). The post-dispersal barriers at degraded sites potentially able to limit plant recruitment include competition from existing plants (Nepstad et al., 1991; Putz and Canham, 1992; Holl, 1998), a lack of appropriate microsites in which to germinate (Eriksson and Ehrlen, 1992; Doust et al., 2006) and seed (and seedling) predation (Holl et al., 2000). The weather conditions following dispersal can also play a critical role in determining the success of seedling establishment and growth (De Steven, 1991).

Favourable micro-sites that enable tree seeds to germinate successfully may be relatively uncommon in the harsh conditions (De Steven, 1991). These sites often have compacted soils and are subject to wide fluctuations in temperature and moisture. Micro-climatic or micro-topographic conditions at a site may need to be altered or ameliorated in some manner to facilitate species reestablishment. Eriksson and Ehrlen (1992) suggest that if micro-site limitation is the critical factor regulating recruitment of a population then a managed or induced increase in microsite availability should lead to an increase in seedling recruitment. Investigations into how direct seeding might be applied to degraded land in tropical and subtropical rainforest regions are limited, even though the technique may have some significant cost advantages (Engel and Parrotta, 2001; Camargo et al., 2002; Sun and Dickinson, 1995).

Some studies have identified weed completion (Engel and Parrotta, 2001; Doust et al., 2006), seed burial of seed (Kitajima and Fenner, 2000; Doust et al., 2006), and site preparation (Doust et al., 2006; Doust et al., 2008) as a major factor affected seed germination and seedling mortality. In order for direct seeding to become a viable rehabilitation method suitable methodologies must incorporate techniques that regularly promote, or at least do not inhibit, the successful establishment of a wide range of species. Such species are likely to have varying seed sizes and life history traits. The goal of this study was to determine how different sowing treatments and light intensity (micro-sites) affected the establishment and growth of various tree species.

2. EXPERIMENTAL METHODS

2.1. Study Site

This study was conducted at Parung Panjang Forest Research Station (lat. 06° 6', long. 106° 20') Bogor, West Java. The altitude of the site is 51 m above sea level. Soil type is podzolik haplik with pH 4.8. The organic matter of soil fertility, Phosphor, and Kalium contents are low. The climate falls into type A according to Schmidt and Ferguson classification, with an annual rainfall between 2000 and 2500 mm (dry season 6-8 moon/year) (Sudrajat, et al., 2006). The original vegetation on the site was dominated by Imperata cylindrica grassland and Schima wallichi coppices, and some locations grown by Acacia mangium.

2.2. Tree Species

Species selection was primarily determined by seasonality and seed availability in the period prior to trial establishment. Seven species that have a diversity of ecological attributes, including a range of species characteristics, seed sizes and pre-sowing treatments were involved in this research (Table 1).
Table 1: Characteristics of seed lots of each species used in direct seeding trials

<table>
<thead>
<tr>
<th>Species</th>
<th>Characteristics and seed size</th>
<th>Locations of seed collection</th>
<th>Pre-sowing treatments</th>
<th>Seed viability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia mangium</em> Willd.</td>
<td>Pioneer, small seed</td>
<td>Bogor, West Java</td>
<td>Soaked in hot water (80° C) for 24 hours</td>
<td>83-92%</td>
</tr>
<tr>
<td><em>Acacia crassicarpa</em> A.Cunn. ex Benth.</td>
<td>Pioneer, small seed</td>
<td>Riam Kiwa, South Kalimantan</td>
<td>Soaked in hot water (80° C) for 24 hours</td>
<td>56-76%</td>
</tr>
<tr>
<td><em>Acacia anulacarpa</em> A.Cunn. ex Benth.</td>
<td>Pioneer, small seed</td>
<td>Bogor, West Java</td>
<td>Soaked in hot water (80° C) for 24 hours</td>
<td>80-84%</td>
</tr>
<tr>
<td><em>Gmelina arborea</em> Roxb.</td>
<td>Pioneer, intermediate size seed</td>
<td>Bogor, West Java</td>
<td>Soaked in water for 30 minutes</td>
<td>85-95%</td>
</tr>
<tr>
<td><em>Intsia bijuga</em> (Colebr.) O. Kuntze</td>
<td>Late stage species, large seed</td>
<td>Carita, Banten</td>
<td>Scarified and then soaked in water for 30 minutes</td>
<td>85-95%</td>
</tr>
<tr>
<td><em>Maesopsis eminii</em> Engl.</td>
<td>Pioneer, intermediate size seed</td>
<td>Cianjur, West Java</td>
<td>Soaked in KNO₃ (2%) for 30 minutes</td>
<td>68-79%</td>
</tr>
<tr>
<td><em>Melia azedarach</em> L.</td>
<td>Pioneer, intermediate size seed</td>
<td>Bogor, West Java</td>
<td>Scarified and then soaked in water for 30 minutes</td>
<td>50-54%</td>
</tr>
</tbody>
</table>

Seed size category based on seed weight, small (<0.01g - 0.099 g), intermediate (0.1 g – 4.99 g), large (>5 g) (Doust et al. 2006)

2.3. Seed Collection and Viability Test

Seeds were collected from parent trees (a minimum of five) in several locations (Table 2.). After collection, *Acacia* spp. and *Intsia bijuga* seed were extracted by dry extraction method. For seeds of *Gmelina arborea*, *Maesopsis eminii*, and *Melia azedarach* (fleshy fruits) were extracted by wet extraction method to remove fleshy parts (Schmidt, 2000).

Estimates of seed quality of small seeded species (*Acacia* spp.) were determined through germination trials conducted in a germinator with top paper method, while for *Gmelina arborea, Intsia bijuga, Maesopsis eminii*, and *Melia azedarach* were conducted in greenhouse used the mixture of soil and sand (1 : 1 v/v) media. Germination percentages were used as a baseline for calculations of species establishment rates in the field experiments.
2.4. Experimental Design

The experimental trials were established according to a factorial design in October 2009. Two factors, openness location and sowing treatment, were applied manually. The seeds were sowed on under tree stands and in open area. The sowing treatments were designed to create different micro-site conditions for germination.

Table 2: Treatment of direct seeding of seeds

<table>
<thead>
<tr>
<th>Sowing treatment and techniques</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>B1</td>
<td>A1B1</td>
</tr>
<tr>
<td>B3</td>
<td>A1B3</td>
</tr>
<tr>
<td>B4</td>
<td>A1B4</td>
</tr>
<tr>
<td>B5</td>
<td>A1B5</td>
</tr>
</tbody>
</table>

Notes: A1 = Under tree stand, distance among shelter trees 6 m; A2 = Open area; B1 = The untreated seeds were sown on the site-soil surface, which had been left uncleared; B2 = The untreated seeds were sown on the site-soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened; B3 = The untreated seed were sown on the site-soil surface which had been cleared and loosened; B4 = The seeds were treated, afterwards sown on the site-soil surface, which had been cleared and loosened; B5 = The seeds were treated, afterwards sown on the site-soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened;

For each species at under tree stand and open area, five treatments were established i.e.: (1) the untreated seeds were sown on the site –soil surface, which had been left uncleared, (2) the untreated seeds were sown on the site –soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened, (3) the untreated seed were sown on the site-soil surface which had been cleared and loosened, (4) the treated seeds, afterwards sown on the site –soil surface, which had been cleared and loosened, and (5) the treated seeds, afterwards sown on the site –soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened. Four replications were used in each treatment consisted experiment plots sized 1 m x 1 m. The established plots were spaced at a minimum of 3 m apart and sowed randomly 100 seeds.

![Figure 1: Sowing treatments](image-url)
2.5. Measurement and Analysis

Assessments of seedlings were carried out at 3 months after seeds were applied. Tree seedlings surviving at the site at the time of monitoring were identified and stem lengths were measured from soil level to the apical tip. Treatment effects on seedling establishment rates and seedling height were assessed by analysis of variance (ANOVA) according to a factorial design. Percentage data were transformed using an arcsine square root transformation as of Zar (1996) prior to statistical analyses, while descriptive statistics presented are of original untransformed data. Post hoc analyses for pair-wise comparisons of means were undertaken using Duncan Multiple Test (α = 0.05).

3. RESULTS AND DISCUSSION

3.1. Viability Tests and Climatic Conditions Over the Study Period

*A. mangium, A. crassicarpa, G. arborea,* and *I. bijuga* showed good germination capacity (>80%). Three species (*A. crassicarpa, M. eminii,* and *M. azedarach*) showed relatively lower germination capacity. All other species in the trial had viabilities of 50–95% (Table 1.).

Growing conditions were favourable during the period of the trial. Mean monthly temperatures varied between 23°C (minimum) and 35°C (maximum), while relative humidity ranged from 51% to 95% (Figure 1). In the first month (October), the rainfall was 134 mm, and increased in November (282 mm), but decreased in December (150 mm).

![Figure 2: Fluctuation of temperature and relative humidity at the under tree stand and open area](image)

3.2. Seedling Establishment

Establishment rates were determined by calculating the number of seedlings present as a percentage of the number of viable seeds sown per plot (shown in Table 3). At 3 months there was a significant difference in seedling establishment as affected by sowing treatments and site openness on each species (*A. mangium*, F = 4.05, p < 0.0005; *A. crassicarpa*, F = 4.34, p < 0.0005; *A. anlacocarpa*, F = 4.73, p < 0.0005; *G. arborea*, F = 7.29, P < 0.0001; *I. bijuga*, F = 19.82, p < 0.0001; *M. eminii*, F = 2.69, p < 0.0005; *M. azedarach*, F = 1.58, p < 0.0005). Higher establishment rates were observed for *A. mangium, A. crassicarpa,* and *A. anlacocarpa* when seeds were treated by soaking seed in hot water (80°C) for 24 hours, afterwards sown on the site-soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened (A1B5). Different result was observed in the case of *G. arborea, I. bijuga, M. emenii,* and *M. azedarach,* they had better establishment at under the stand. *G. arborea* had the best establishment at under the stand used the treated seeds,
afterwards sown on the site-soil surface, which had been cleared and loosened (A2B2). *I. bijuga, M. emenii* and *M. azedarach* had the best establishment at under the stand with the treated seeds, afterwards sown on the site-soil surface, which had been holed with 2 – 3 cm depth, cleared and loosened (A2B5).

Table 3: Duncan’s multiple range test regarding the site effect on seedling survival of seven species

<table>
<thead>
<tr>
<th>Treatment</th>
<th>AM</th>
<th>AC</th>
<th>AA</th>
<th>GA</th>
<th>IB</th>
<th>ME</th>
<th>MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1B1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 e</td>
<td>1 d</td>
<td>3 e</td>
<td>6 f</td>
</tr>
<tr>
<td>A1B2</td>
<td>5 e</td>
<td>6 e</td>
<td>12 c</td>
<td>56 a</td>
<td>2 d</td>
<td>46 e</td>
<td>11 ef</td>
</tr>
<tr>
<td>A1B3</td>
<td>5 e</td>
<td>7 e</td>
<td>18 b</td>
<td>49 b</td>
<td>1 d</td>
<td>10 de</td>
<td>12 e</td>
</tr>
<tr>
<td>A1B4</td>
<td>21 a</td>
<td>20 b</td>
<td>16 bc</td>
<td>7 d</td>
<td>9 c</td>
<td>59 b</td>
<td>27 b</td>
</tr>
<tr>
<td>A1B5</td>
<td>22 a</td>
<td>28 a</td>
<td>41 a</td>
<td>12 c</td>
<td>16 b</td>
<td>54 bc</td>
<td>23 c</td>
</tr>
<tr>
<td>A2B1</td>
<td>0</td>
<td>3 cd</td>
<td>2 e</td>
<td>0</td>
<td>5 cd</td>
<td>5 e</td>
<td>10 ef</td>
</tr>
<tr>
<td>A2B2</td>
<td>1 d</td>
<td>2 d</td>
<td>7 d</td>
<td>57 a</td>
<td>10 bc</td>
<td>56 b</td>
<td>28 b</td>
</tr>
<tr>
<td>A2B3</td>
<td>0</td>
<td>2 d</td>
<td>4 de</td>
<td>45 b</td>
<td>14 bc</td>
<td>19 d</td>
<td>15 d</td>
</tr>
<tr>
<td>A2B4</td>
<td>5 e</td>
<td>8 e</td>
<td>13 c</td>
<td>14 c</td>
<td>21 b</td>
<td>62 a</td>
<td>15 d</td>
</tr>
<tr>
<td>A2B5</td>
<td>17 b</td>
<td>2 d</td>
<td>13 c</td>
<td>14 c</td>
<td>58 a</td>
<td>64 a</td>
<td>55 a</td>
</tr>
</tbody>
</table>

*AM=Acacia mangium; AC=Acacia crassicarpa; AA=Acacia aulacocarpa; GA=Gmelina arborea; IB=Intsia bijuga; ME=Maesopsis eminii; MA=Melia azedarach;* Figures in the column followed by the same letters are not significantly different at 99% level a > b.

Figure 3: Seedling establishment of *Acacia mangium, Acacia crassicarpa,* and *Gmelina arborea* at 1 month age

**3.3. Seedling Height**

After three months, the differences on seedling height only occurred on Acacia spp. The two openness sites (open area and under the stand) were significantly affected to seedling height of Acacia spp. (*A. mangium*, F= 20.03, p<0.0001; *A. crassicarpa*, F=10.93, p<0.0001; *A. aulacocarpa*, F=17.75, p<0.0001). The best growing for the three Acacia was open area. On the contrary, the trend of other species (*G. arborea, I. bijuga, M. eminii,* and *M. azedarach*), the best height
The microsite differences created by the various sowing treatments were found to have significant effects on the numbers of seedlings established both at the open area and under the stand. The uncleared sites/plots (B1) consistently showed the lowest overall seedling establishment of all openness site conditions. In contrast, treatments B 4 and B5 where the site was cleared with minimal soil disturbance, proved to be the most successful treatments with the highest levels of seedling establishment recorded. For Acacia spp., treatment 5 (B5) at open area (A1) achieved higher establishment rates than other treatments, while for other species, treatment 5 (B5) at under the stand (A1) resulted the best seedling establishment.

The generally lower seedling establishment recorded in the uncleared sites may have been a result of grass barrier so less of contact the seed with the soil surface, especially for small seeds.
Modification of seed–water relationships through changing contact with soil layers or exposure to the atmosphere has been long established in the literature as a major factor affecting plant recruitment from seed (Harper et al., 1964), and the micro-topography of the surface of the soil has been known to determine the density of safe-sites available for germination (Fenner, 1985). Woods and Elliott (2004) have also found that burial significantly increased germination percentage of direct sown seeds in experiments conducted at forest restoration sites in Northern Thailand.

Pioneer species (*Acacia* spp.) established in higher proportions at open area site than at under the stand. The situation showed that *Acacia* spp. seeds required more light to germinate. *Acacia* spp. also had higher seedling height at open area than at under the stand. For other species (*G. arborea, I. bijuga, M. eminii*, and *M. azedarach*), seedling establishment and height have been found at under the stand. In general, seedling establishment rates and seedling height were high, especially in sowing treatments where seeds were buried (2 – 3 cm depth). This result suggests that soil coverage was a major determinant of the success of germination of the species tested.

![Figure 6: (a) Weed competition; and (b) seedling predation](image)

The success of direct seeding was affected by capacity of species to compete with the weed. Weeds recovered quickly after the eradication treatments at all sites and pressured the seedling growth both above-ground (root competition) and below-ground (shoot competition) (Figure 5 a). *I. bijuga* and *M. azedarach* seedling growth relatively cannot compete with the weed as they grew stagnant after seedling phase. The low seedling establishment rates of these species may also be affected by predation. In degraded land, seeds are vulnerable to predation and the risk of seed mortality is increased due to extreme conditions at the soil surface (e.g. high soil temperatures (Zimmerman et al., 2000). Seed loss to predation has been found to be higher for seed exposed on the soil surface than for buried seed (Crawley, 2000). Seed predation rates in the region may also increase in dry season periods in response to seasonal variation in the availability of food resources. Some insect also attacked seedling of some species especially *I. bijuga*, that caused lose of most of above-ground biomass and then caused seedling death (Figure 5 b). The most promising species to use will be those that have at least one (but preferably more than one) of the following characteristics (Doust et al., 2008), such as: easily available seed (available in large quantities and over long periods); high seed viability and storage potential; rapid and consistent germination; deep root extension for situations where there is significant shallow rooted weed growth; high growth rate potential; low sensitivity to competition.
4. CONCLUSIONS

This study indicated that direct sowing can be a feasible establishment method at early successional sites for certain rain forest tree species. The micro-site effects on species establishment observed in this study suggest that the best results from direct seeding will be available when there is an opportunity to manipulate the soil environment to create appropriate microsites. Greatest seedling establishment was achieved by the implementation of seed treatment and followed by seed sowing on the site surface which had been holed with 2 – 3 cm depth, cleared and loosened. This research results could be used for direct seeding of the selected species. Testing and selection of tree species suitable for planting in targeted habitats prior to major direct seeding efforts will improve the efficiency of rehabilitation projects. Some species in this study such as A. crassicarpa, A. mangium, A. aulacocarpa, M. eminii, and G. arborea had potency for implementation of direct seeding.

5. REFERENCES


Appendix 1. Recapitulation of analysis of variance on seedling percentage and growth of seven tree species

<table>
<thead>
<tr>
<th>Species</th>
<th>Treatment</th>
<th>Parameters</th>
<th>Survival</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acacia mangium</strong></td>
<td>A</td>
<td>9.37 **</td>
<td>20.03 **</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.96 *</td>
<td>0.98 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A*B</td>
<td>4.05 *</td>
<td>1.66 ns</td>
<td></td>
</tr>
<tr>
<td><strong>Acacia crassicarpa</strong></td>
<td>A</td>
<td>8.33 *</td>
<td>10.93 **</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.99 *</td>
<td>1.81 tn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>4.34 *</td>
<td>0.00 tn</td>
<td></td>
</tr>
<tr>
<td><strong>Acacia aulacocarpa</strong></td>
<td>A</td>
<td>12.68 *</td>
<td>17.57 **</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.09 *</td>
<td>2.34 tn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>4.73 *</td>
<td>0.00 tn</td>
<td></td>
</tr>
<tr>
<td><strong>Gmelina arborea</strong></td>
<td>A</td>
<td>24.67 **</td>
<td>1.26 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>15.65 **</td>
<td>1.65 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>7.29 **</td>
<td>1.74 ns</td>
<td></td>
</tr>
<tr>
<td><strong>Intsia bijuga</strong></td>
<td>A</td>
<td>32.84 **</td>
<td>0.17 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>19.82 **</td>
<td>1.33 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>5.65 **</td>
<td>1.61 ns</td>
<td></td>
</tr>
<tr>
<td><strong>Maesopsis eminii</strong></td>
<td>A</td>
<td>28.93 **</td>
<td>0.28 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>38.62 **</td>
<td>0.96 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>2.69 *</td>
<td>1.66 ns</td>
<td></td>
</tr>
<tr>
<td><strong>Melia azedarach</strong></td>
<td>A</td>
<td>15.71 **</td>
<td>0.58 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>26.82 *</td>
<td>1.24 ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AB</td>
<td>1.58 *</td>
<td>0.64 ns</td>
<td></td>
</tr>
</tbody>
</table>

A=site conditions (under tree stand and open area); B=sowing treatments; AB=interaction factor A and factor B; ns = not significantly at 95 %; ** = significantly different at 99 %; * = significantly different at 95 %.
Hunting System and People Perception on Deer Conservation Efforts in The WoloTadho Nature Reserve

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ABSTRACT

Timor deer (Cervus timorensis) is the wildlife that has many benefits. Deer horns can be used as a traditional medicine. Deer meat is used as a protein source. While the leather is used as handicrafts. Due to many benefits, deer are hunted by people. Deer hunting has caused deer population decreased continuously. This study aims to identify deer hunting system and to know people perception on deer conservation efforts. The study was conducted in WoloTadho Nature Reserve. Data was collected through interview. Respondents were selected purposively. Selected respondents as many as 26 people who live around the WoloTadho Nature Reserve. The results showed that hunting is done for one time within a year. The hunt are related to the local traditional rituals in the past. Deer hunting is only conducted by the local community. People use simple equipment. They use snares. However, deer hunting now is followed by hundreds of people from different regions. Hunting activities became difficult to be monitored. Deer hunting causes forest fires because people use fire for hunting. People perception about deer conservation efforts is good. Generally, they know that the deer is a protected animal and they support deer conservation efforts.

Keywords: Deer, WoloTadho Nature reserve, perception

1. INTRODUCTION

1.1. Background

Timor deer (Cervus timorensis) is one of the wildlife that has many benefits. Deer horns can be used as traditional medicine. Deer meat is used as a protein source. While the leather is used as handicraft. Because of that, many deers are hunted by people. Deer hunting causes the deer population has decreased continuously.

Timor deer need a good habitat to breed. Conservation area should be the area that supports deer population. The province of East Nusa Tenggara is one of the good habitat for deer conservation. There are some Nature Reserves, National Parks and Wildlife where protect and conserv deer in East Nusa Tenggara.

Wolo Tadho nature reserve is one of the Timor deer habitat. In this area, East Deer can regenerate naturally. The factor that support deer conservation effort because of suitable of the habitat. WoloTadho Nature Reserve consists of forests and grasslands. Forest used as a shelter while the field is used as a dining area. Wolo tadho area designated as a Nature Reserve in order to protect the flora and fauna that exist in the region.

Contrary to that, forest dwellers reduction deer population. in the area of good habitat, deer population can decline because of hunting activities. if not controlled well, the activities can lead to the deer population extinction.

Deer conservation efforts need to take an attention at social aspects. Deer population decline is largely due to hunting behavior. Public support for the preservation of the deer is needed to
conserv deer. Regulations relating to the preservation of the deer need to be followed by the public and well-executed. Violation of these regulations result in decrease in the deer population.

1.2 Problem Formulation

Hunting deer in the nature reserve of Wolo Tadho held only once in a year. The hunting events related to local traditional rituals. The research question is how the implementation of hunting deer in the Nature Reserve Wolo tadho, what is its impacts and how people's perception of deer conservation efforts in the study site.

1.3 Goals

1. Knowing the system hunting deer in the WoloTadho Nature Reserve
2. Knowing the public perception of conservation efforts deer in Nature reserves Wolo Tadho

2. METHODS

2.1 Location and Time

This study was conducted in Village District TadhoRiungNgada. The village is adjacent to the WoloTadho Nature Reserve. Primary data collection is carried out in 1 month in September 2012.

2.2 Materials and Tools Research

Objects of this study are forest dwellers in the WoloTadho Nature Reserve. While the tools used in this study is a questionnaire, stationery, maps of the location of the research, recording devices, and documentation tools.

2.3 Sampling Methods

Population sampling in this study were all heads of families residing in the village of WoloTadho. Twenty six households were taken as a sample that choosen purposively.

2.4 Data Collection Method

The main tool in this study is a list of questions). Interviews were conducted by asking questions that have been prepared. The form of the questions asked in the form of a semi-open questions that respondents are welcome to choose alternative answers which have been provided, but if there is no answer to that question then responden are given the opportunity to express the answer.

3. RESULTS

3.1. Deer Population

According to respondents, the deer population in the Wolo Tadho Nature Reserve was rare. This indicates the deer population in the Nature Reserve WoloTadho decreased. Cause of the population decline is the presence of deer hunting people in the Nature Reserve WoloTadho.
Table 1: Deer population according to respondent

<table>
<thead>
<tr>
<th>No</th>
<th>Deer population</th>
<th>Amount of respondent</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>More frequently found</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Fixed</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Increasingly rare</td>
<td>26</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Data processed from interviews, 2012

According to respondents, 20 years ago the population of deer in the Wolo Tadho Nature Reserve is still enough. They found the deer in the forest or on the farm. Deer are also often seen on the beach. But now the deer population has been greatly reduced. The respondents have rarely met deer. Allegedly poaching deer population cause decreased. However, poaching is difficult to detect. Local people used to hunt wild boar. Sometimes when hunting wild boar they found the deer. According to the respondents if they find the deer, they arrested him.

3.2 Hunting System

Wolo Tadho Nature Reserve does not have special hunting system. Hunting activity follow the national hunting regulation. This makes it difficult to manage the hunting in Wolo Tadho Nature Reserve that affect in declining deer population continuously.

During the Dutch Government (1908-1945), the activity of deer hunting in the forest area of Wolo Tadho was controlled by a king. At the time the forest area of Wolo Tadho in the suzerainty of the King of Riung who subject to the Government of the Netherlands. The king of Riung named Ismail Petor Sila. He organized the deer hunting in Wolo Tadho Nature Reserve. Following the instruction of the king, the deer hunting activity in the forest area of Wolo Tadho only carried out once in a year. The tools used is limited to spears and snares so that did not damage the environment. The deer hunters were prohibited to use fire. The deer hunting in Wolo Tadho Nature Reserve associated with a local traditional event. People believe that the deer hunting activity can avoid diseases that attack the inhabitants.

The population of deer continue to decline. To anticipate, the Dutch Government issued the law of ordinance and wildlife animal protection (1931) No.134 and 266, which was issued because the population become declining and critical. However the traditional hunting in Wolo Tadho Nature Reserve is not prohibited. That circumstances still continue with indigenous ritual as a reason.

During the administration of the Republic of Indonesia, the deer is categorized as protected animal. The Indonesia Government issued Law No. 5 (1990) on the Conservation of Natural Resources and Ecosystems stated that deer is one of the endangered species which is need to be protected. By this rules then deer can not be hunted by people anymore. Nevertheless hunting practices in the Nature Reserve of Wolo Tadho is still going, resulting in drastic population declines.

According to Darori (2011) Local communities can hunting traditionally without the need to have a hunting certificate, hunting guide and pay license fees (Government regulation/PP. 13 of 1994 section 14). As an explanation, there are any criteria for traditional hunters, i.e. residing in districts around the hunting area, the prey is used for customs purposes, and for the fulfillment of the purposes of everyday life, using traditional tools. For prey who traded using traditional tools, should have a hunting license, and pay hunting licence fee (Government regulation/PP. 13 year 1994 explanation of Article 14 and the Regulation of the Minister of Forestry. P. 18/Menhut-II/2010 Chapter II and Chapter III of the Permit Hunting and Hunting Permit Procedures Obtain). This hunting activities applies in a limited hunting season (PP. Explanation...
For trading activities, plants and wildlife that can be traded is not protected species and obtained from captivity and taking or catching of the nature (PP. 8, 1999 article 18). Furthermore PP. 8, 1999 article 19 and the explanation mentions also that trading can be done on a limited scale by the people who live in the hunting area and around hunting park. In his explanation, trading activities on a limited scale is to collect and sell their traditional hunting using traditional tools made by people who live in and around the area of hunting and hunting parks. Government Regulation no. 13 of 1994 explanation of Article 9 defines traditional hunting tools that can be used as a tool of traditional hunters such as snares, traps, nets, spears, arrows and chopsticks.

In addition to traditional hunting, the deer conservation in WoloTadho Nature Reserve is threatened by illegal hunting activities. Illegal hunting is very difficult to detect by the manager of the WoloTadho Nature reserve. Local hunting is done without considering the time. Actors generally do not care about hunting deer conservation. Illegal hunting must be stopped to preserve the deer.

The hunting system should be in accordance with the birth rate in deer population according to Santosa (2008) level of the average deer birth rate is 0.19. This figure means that from 100 deers only born 19 individual of deer per year. The recent research in the Riung Nature Reserve which is closest to the WoloTadho estimated there are 72 individu of deer. With a birth rate of 0.19 then the value of the number of deer that may be hunted each year maximum 13 individual. Restrictions on the number of game animals have not been regulated in Riung hunting system.

To conserve the deer, hunting activity should be limited. Illegal hunting must be stopped so that the manager of the WoloTadho Nature Reserve (BKSDA/Natural Resource Conservation Center) can protect the deer and control the hunting activities. Beside of that the manager can determine existing deer population in the nature reserve and deer that has been hunted. The hunting is allowed with the clear hunting system. The system includes rules in hunting, staff of hunting controller, the tools used, the sanctions and the parties which have responsibilities for hunting.

The system that can ensure the preservation of deer hunting in WoloTadho Nature Reserve is the hunting which held only once a year. Number of deer to be hunted not more than birthrate, the tools used are not using fire, hunting members limited for indigenous peoples who live around the nature reserve, and hunting activities led by traditional local leaders who can control his members. The hunting rules should be applied to support a system that ensures the preservation of deer hunting in the WoloTadho Nature Reserve.

In the hunting system, the latest populations should be known in the WoloTadho Nature Reserve. Data of population is required to determine the number of the deer that can be hunted each a year. It is also important that hunting controller not exceed the limit of animals that can be hunted and hunting activity do not allowed to using fire which can cause forest fires. Hunting time should be regulated. Hunting can only be done once a year. This is to ensure the deer population to reproduce. Deer hunting system improvements in the Wolotadho Nature Reserve include hunting time, the tools used, the controller (gamekeeper), inhabitans who have the right to hunt, game warden, as well as hunting regulations.
3.3 Public Perception of Deer Conservation

Most respondents have a perception that deer should be protected. Extension activities that carried out by forest department and the local government is a factor that influence the public perception. Information about deer as protected animals is known from the forest officials, village government and radio.

In addition to respondents who answered the Timor deer as protected animals, there are also respondents who answered that deer are not protected animal (11%) and some of them do not know the status of deer (16%). Respondents should be aware. Although few in number but very effect on the preservation of deer. Illegal deer hunting is generally done by people who do not know the status of the Timor deer.

Table 2: Perception of people on deer

<table>
<thead>
<tr>
<th>No</th>
<th>Deer status</th>
<th>Number of respondent</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a. Protected animal</td>
<td>19</td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>b. Non protected animal</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>c. Do not know</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>26</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Primary data, 2012

Other people's have perceptions that deer live in the forest. When feeding times, deer coming out to the field. Forest is the best place for deer to hide. Knowledge of the deer habitat is used by the public for hunting the deer in the forest.

Table 3: Public perception of deer habitat

<table>
<thead>
<tr>
<th>No</th>
<th>The Deer Habitat</th>
<th>Number of respondent</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forest</td>
<td>22</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>Grass land</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Others</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>26</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Primary data, 2012

Some wildlife species showed declining in population due to poor public perception of the impact in presence of wildlife. Table 4 illustrates the public's perception of the impact of the existence of Timor deer.

Most respondents (62%) stated that the existence of Timor deer do not cause a negative impact in destruction of agricultural crops. According to the respondents Timor deer rarely damaging farmland. The main reason of deer hunting is not cause by the deer who damage the farmland, but tent to reason because deer have a delicious meat for consumption and can be sold.

Table 4: Respondents perception of the impact in deer precences

<table>
<thead>
<tr>
<th>No</th>
<th>The impact of deer</th>
<th>Number of respondent</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disturb</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Not Disturb</td>
<td>16</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>26</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Primary data, 2012

In addition to conserve deer in their habitat, the conservation can also be done by captivity (ex-situ). To support the deer Ex situ conservation, Government has published the Decree of the Minister of Agriculture. 362/Kpts/TN, 120/5/1990 dated May 20, 1990 that the deer classified
into animals that can be cultivated as other livestock, including business license regulation. Table 5 presents the data on the ex-situ conservation.

The results showed that most respondents have the perception that they could not cultivate the deer. With this perception means that deer conservation efforts can not be done as ex-situ conservation in the village community. Most of the people admitted that they had never cultivated the deer. Deer conservation models that can be done is to keep the deer and their habitat that does not disturbed by humans. Deer cultivation can only be done by government and non-government organizations that can cultivate the deer in captivity.

According to Suratini (2004) lack of public knowledge about the potential for deer and farming methods or maintenance of deer causing less people interested in the deer breeding. In addition, society in general has had livestock such as cows and goats are more easily to be sold.

The explanation above showed that the general public has the perception that support conservation deer. However there is still a small group of people who do not perceive the conservation of deer. The management should pay attention to the small group. Although the numbers are small, but very influential in the preservation of deer in the WoloTadho. Nature Reserve

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

1. Deer hunting systems in the Nature Reserve WoloTadho need to be fixed to support the preservation of the deer in the WoloTadho nature reserve. System of improvement consist of time hunting, tool use, hunting and surveillance society has the right to hunt.
2. Communities around the Wolo Tadho Nature Reserve have the perception that deer as a protected species, habitats in the forest, and farm land not interfere. With this perception, it meant that there are already provide enough support from the community to conserve deer. However there is still a small group of people who are less support to preservation of deer. Although the numbers are small, the government should get more attention because it influences the preservation of deer.

4.2 Recomendations

Based on the research results, we provide suggestions as follow:

1. The government made system that supports preservation of deer hunting.
2. Government socialize a small group of people who do not care about the preservation of deer.

5. REFERENCES


Anon. 1990. Undang-undang No. 5 tahun 1990 tentang Konservasi Sumber Daya Alam Hayati dan Ekosistemnya.


Genetic Diversity of Castor Bean (*Ricinus communis* L.)
Germplasm from Indonesia and Neighboring Countries Assessed by Morphological Marker

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Genetic Diversity of Castor Bean (*Ricinus communis* L.) Germplasm from Indonesia and Neighboring Countries Assessed by Morphological Marker

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**ABSTRACT**

Genetic diversity of the castor bean (*Ricinus communis* L.) from Indonesia and neighboring countries were evaluated based on morphological and agronomic characters during vegetative and generative growth phases in the field at the time of exploration. This study aimed to identify variation between castor bean germplasm from Indonesia and neighboring countries assessed by morphological markers. Exploration was carried out in three provinces namely West Java, East Java and West Nusa Tenggara. Castor bean acquired from neighboring countries was germplasm belonging to PT. Better Earth Green Energy, a company in West Nusa Tenggara. The results of exploration obtained 56 castor bean accessions. Observation showed that 56 accessions had morphological characters with high variability. Petiole length is the characters that has the most extensive range value (50). Variability value reaches 98. A dendogram of qualitative morphological characters showed that at 72 similarity levels, the 56 accessions could be classified into three main groups. This indicated that the genetic diversity of castor bean accessions observed is low. Genetic transformation and mutation are ways to increase genetic variation of castor beans.

**Keywords:** *Ricinus communis* L., characterization, morphological marker, cluster analysis, castor bean

1. **INTRODUCTION**

Castor bean (*Ricinus communis* L.) is an important oil-producing plant in the Euphorbiaceae family. It has a great potential to be developed as a source of bioenergy, lubricant oil, and industrial raw materials. This plant is originated from the Africa continent (Weiss, 1971; Heyne, 1987), in the eastern part of Africa (Chevallier 2001), possibly in Ethiopia (Weiss, 1971). Most people know this plant as a medicinal plant, although the seeds contain very harmful chemicals (Challoner, 1990; Foster & Duke, 1990; Deshpande & Chaturvedi, 2012). It has potential to be used as a natural dye for soothing shades used to make Ayurvedic Vastram textiles which fight against skin disease (Deshpande & Chaturvedi, 2012). Another study done by Rao, Mittal, Sunhanshu, & Menghani (2013) found that methanol extracts from castor bean possess effectual antioxidant and antimicrobial substances which may be rationalized on the basis of using this plant’s extract as folkloric remedies.

Castor bean is monotypic genus (n = 20), primarily wind-pollinated and all known variants, including previously described species, intercross readily and produce fertile offspring (Shifriss, 1955). In Indonesia, the varieties released are limited, so far most of them are landrace, which is not clear its characters and quality yet. Castor bean characterization can be done based on morphological and molecular markers.
This study aimed to identify variation between castor bean germplasms from Indonesia and neighboring countries through morphological markers.

2. EXPERIMENTAL METHODS

Exploration in Indonesia was carried out in several locations that represent the three provinces of West Java, East Java and West Nusa Tenggara. Accession of Thailand and The Philippines was obtained through Terms of Research collaboration between SBRC-IPB and PT BEGE (Better Earth Green Energy). Selected plants in the field were estimated to be more than three years old. Plants were healthy and were bearing or had borne fruit. A list of the plants studied is shown in a Table 1 below.

Table 1: Accessions of castor bean collected from exploration

<table>
<thead>
<tr>
<th>No</th>
<th>Code</th>
<th>Origin</th>
<th>No</th>
<th>Code</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GAL-1</td>
<td>Galuga-Bogor, WJ</td>
<td>29</td>
<td>BAGET-2</td>
<td>Lopok-Sumbawa Besar Timur,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WNT</td>
</tr>
<tr>
<td>2</td>
<td>GG-1</td>
<td>Gunung Gede-Bogor, WJ</td>
<td>30</td>
<td>SER-1</td>
<td>Moyo-Sumbawa Besar, WNT</td>
</tr>
<tr>
<td>3</td>
<td>GAL-2</td>
<td>Galuga-Bogor, WJ</td>
<td>31</td>
<td>BAGET-1</td>
<td>Lopok-Sumbawa Besar Timur,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>WNT</td>
</tr>
<tr>
<td>4</td>
<td>PHIL-1</td>
<td>Philippine</td>
<td>32</td>
<td>LANG-1</td>
<td>Lape-Sumbawa Besar, WNT</td>
</tr>
<tr>
<td>5</td>
<td>PLAM-1</td>
<td>Plampang-Sumbawa, WNT</td>
<td>33</td>
<td>AIK-1</td>
<td>Aikmel Utama-Lotim, WNT</td>
</tr>
<tr>
<td>6</td>
<td>MER-1</td>
<td>Merangi-Sumbawa Timur, WNT</td>
<td>34</td>
<td>TAN-1</td>
<td>Labuan Haji-Lotim, WNT</td>
</tr>
<tr>
<td>7</td>
<td>LAB-1</td>
<td>Labuan-Sumbawa Besar, WNT</td>
<td>35</td>
<td>PEG-1</td>
<td>Panggabay-Lotim, WNT</td>
</tr>
<tr>
<td>8</td>
<td>BAG-1</td>
<td>Warasaba-Lotim, WNT</td>
<td>36</td>
<td>LAB-2</td>
<td>Labuan-Lotim, WNT</td>
</tr>
<tr>
<td>9</td>
<td>THAI-101</td>
<td>Thailand</td>
<td>37</td>
<td>IJOB-1</td>
<td>Ijobalit, Labua Haji, WNT</td>
</tr>
<tr>
<td>10</td>
<td>MAL-1</td>
<td>Malang, EJ</td>
<td>38</td>
<td>LAB-3</td>
<td>Panggabay-Lotim, WNT</td>
</tr>
<tr>
<td>11</td>
<td>Phil-2</td>
<td>Philippine</td>
<td>39</td>
<td>CIB-1</td>
<td>Cibadak-Sukabumi, WJ</td>
</tr>
<tr>
<td>12</td>
<td>LABPAN-2</td>
<td>Sambelie-Lotim, WNT</td>
<td>40</td>
<td>CIS-2</td>
<td>Cisarua-Bogor, WJ</td>
</tr>
<tr>
<td>13</td>
<td>LABPAN-1</td>
<td>Sambelie-Lotim, WNT</td>
<td>41</td>
<td>SAL-3</td>
<td>Salabintana-Sukabumi, WJ</td>
</tr>
<tr>
<td>14</td>
<td>MER-2</td>
<td>Merangi-Sumbawa Timur, WNT</td>
<td>42</td>
<td>IJOB-2</td>
<td>Ijobalit, Labua Haji, WNT</td>
</tr>
<tr>
<td>15</td>
<td>GP-1</td>
<td>Gunung Pangrango-Bogor, WJ</td>
<td>43</td>
<td>KED-1</td>
<td>Purwoasih, Kediri, EJ</td>
</tr>
<tr>
<td>16</td>
<td>CJR-4</td>
<td>Cianjur, WJ</td>
<td>44</td>
<td>PON-1</td>
<td>Jenengan, Ponorogo, EJ</td>
</tr>
<tr>
<td>17</td>
<td>SAL-1</td>
<td>Salabintana-Sukabumi, WJ</td>
<td>45</td>
<td>PAS-1</td>
<td>Nguling, Pasuruan, EJ</td>
</tr>
<tr>
<td>18</td>
<td>SAL-2</td>
<td>Salabintana-Sukabumi, WJ</td>
<td>46</td>
<td>PAS-2</td>
<td>Nguling, Pasuruan, EJ</td>
</tr>
<tr>
<td>19</td>
<td>SAL-4</td>
<td>Salabintana-Sukabumi, WJ</td>
<td>47</td>
<td>MAD-1</td>
<td>Ngeger, Madiun, EJ</td>
</tr>
<tr>
<td>20</td>
<td>SAL-5</td>
<td>Salabintana-Sukabumi, WJ</td>
<td>48</td>
<td>JOM-2</td>
<td>Kedung Mulyo, Jombang, EJ</td>
</tr>
<tr>
<td>21</td>
<td>CIS-1</td>
<td>Cisarua-Bogor, WJ</td>
<td>49</td>
<td>PON-2</td>
<td>Babatan, Ponorogo, EJ</td>
</tr>
<tr>
<td>22</td>
<td>CIS-3</td>
<td>Cisarua-Bogor, WJ</td>
<td>50</td>
<td>MAL-3</td>
<td>Lawang, Malang, EJ</td>
</tr>
<tr>
<td>23</td>
<td>CIS-4</td>
<td>Cisarua-Bogor, WJ</td>
<td>51</td>
<td>GRE</td>
<td>Dumpring, Gresik, EJ</td>
</tr>
<tr>
<td>24</td>
<td>GP-3</td>
<td>Gunung Pangrango-Bogor, WJ</td>
<td>52</td>
<td>KED-2</td>
<td>Pare, Kediri, EJ</td>
</tr>
<tr>
<td>25</td>
<td>GP-4</td>
<td>Gunung Pangrango-Bogor, WJ</td>
<td>53</td>
<td>PRO</td>
<td>Tungon Ulon, Probolinggo, EJ</td>
</tr>
<tr>
<td>26</td>
<td>CIB-2</td>
<td>Cibadak-Sukabumi, WJ</td>
<td>54</td>
<td>MAD-2</td>
<td>Delopo, Madiun, EJ</td>
</tr>
<tr>
<td>27</td>
<td>THAI-102</td>
<td>Thailand</td>
<td>55</td>
<td>LAM</td>
<td>Tikung, Lamongan, EJ</td>
</tr>
<tr>
<td>28</td>
<td>THAI-103</td>
<td>Thailand</td>
<td>56</td>
<td>MAD-3</td>
<td>Kebun Siri, Madiun, EJ</td>
</tr>
</tbody>
</table>

*Note: Abbreviation for provinces; WJ: West Java; EJ: East Java, WNT: West Nusa Tenggara
2.1 Morphological Analysis

Data was recorded of both qualitative and quantitative characters. Qualitative characters of the germplasm was determined visually by color and shape particularly. The characters included stem (old stem color and presence of cuticle), leaf (number of lobes, tip shape, young leaf color, old leaf color, leaf texture, petiole color, cuticle, serrated edge, and presence of hair), fruit (presence of hair, old skin color, young skin color, and shape), and seed/grain (color and shape). Quantitative characters consisted of main tree diameter, petiole length, leaf length, and leaf width. The mean value of each character for each accession was calculated and subjected to descriptive statistical analysis i.e., standard deviation, variance and standard error, using statistical software, MINITAB 14.

2.2 Cluster Analysis

Morphological characters of castor bean accession data collected are classified and hierarchical cluster used statistical software of SPSS 15. Genetic distance between accession were analyzed based on their similarity into a dendrogram.

3. RESULTS AND DISCUSSION

Variability analysis was performed on the 56 castor bean accessions. The morphological characters varied though it is a monotypic genus (Table 2). Young leaf color, old leaf color, and seed color varied greatly among castor bean germplasm observed.

Table 2: Summary of qualitative characters registered in 56 castor bean accessions

<table>
<thead>
<tr>
<th>Character</th>
<th>Number of Classes</th>
<th>Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old stem color</td>
<td>12</td>
<td>brown, green, whitish red, reddish, red, white, yellowish green, reddish brown, gray, whitish brown, whitish green, light green</td>
</tr>
<tr>
<td>Cuticle</td>
<td>1</td>
<td>present-thick</td>
</tr>
<tr>
<td><strong>Leaves</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tip shape</td>
<td>1</td>
<td>sharp</td>
</tr>
<tr>
<td>Finger number</td>
<td>4</td>
<td>6, 7, 8, 9</td>
</tr>
<tr>
<td>Young leaf color</td>
<td>13</td>
<td>greenish brown, red, light green, purple, green, greenish purple, purplish green, reddish purple, purplish light green, greenish red, brownish green &amp; dark green alternating, reddish green, dark green</td>
</tr>
<tr>
<td>Old leaf color</td>
<td>3</td>
<td>green, dark green, purple</td>
</tr>
<tr>
<td>Leaf texture</td>
<td>1</td>
<td>smooth</td>
</tr>
<tr>
<td>Petiole color</td>
<td>6</td>
<td>red, greenish red, green, reddish green, light green, purple</td>
</tr>
<tr>
<td>Cuticle</td>
<td>1</td>
<td>present-very thin</td>
</tr>
<tr>
<td>Serrated edge</td>
<td>1</td>
<td>present</td>
</tr>
<tr>
<td>Hair</td>
<td>1</td>
<td>absent</td>
</tr>
<tr>
<td><strong>Fruit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hair</td>
<td>1</td>
<td>present</td>
</tr>
<tr>
<td>Old skin color</td>
<td>5</td>
<td>reddish green, brown, black, gray, and yellow</td>
</tr>
<tr>
<td>Young skin color</td>
<td>2</td>
<td>green, purplish pink</td>
</tr>
<tr>
<td>Shape</td>
<td>3</td>
<td>ellipsis, round-ellipsis, round</td>
</tr>
<tr>
<td><strong>Seed/Grain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>13</td>
<td>black and brown spots, black and white spots, reddish light brown spots, brown and white spots, brown and whitish spots, brown and yellowish spots, brown and light brown spots, dark brown and light brown spots, dark brown and light brown spots and white spots dark brown and white spots, white and brown spots, white and dark brown spots, and white light brown spots</td>
</tr>
<tr>
<td>Shape</td>
<td>2</td>
<td>ellipsis, round</td>
</tr>
</tbody>
</table>
Descriptive statistical analysis was performed on variables observed in each accession (Table 3). Petiole length is the character with the most extensive range value (50) and its variability value reaches 98.01. The average value of this character was 26.47 ± 9.9. Leaf length and stem perimeter had the lowest range, i.e. 35, with respective median values of 19.42 ± 8.882 and 29.51± 8.170. Because the value of deviation from the long leaves is smaller than stem perimeter, the variability value is the lowest among the observed characters.

Table 3: Statistical summary of quantitative characters registered in 56 castor bean accessions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Error</th>
<th>Variance</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (cm)</td>
<td>6.18</td>
<td>0.38</td>
<td>78.90</td>
<td>2.87</td>
<td>14.01</td>
</tr>
<tr>
<td><strong>Leaves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petiole length (cm)</td>
<td>26.47</td>
<td>1.32</td>
<td>98.01</td>
<td>9</td>
<td>59</td>
</tr>
<tr>
<td>Leaf length (cm)</td>
<td>29.51</td>
<td>1.09</td>
<td>66.75</td>
<td>17</td>
<td>52</td>
</tr>
<tr>
<td>Leaf width (cm)</td>
<td>31.96</td>
<td>1.15</td>
<td>74.52</td>
<td>17</td>
<td>57</td>
</tr>
</tbody>
</table>

Based on cluster analysis on qualitative characters (Figure 1), at 72% similarity level, the accession group was divided into three groups. This result is similar to research by Goodarzi, Darvishzadeh, Hassani, & Hassanzaeh (2011), which showed that Iranian castor bean germplasm had low genetic variability.

![Dendrogram](image)

Figure 1: A dendrogram of 56 castor bean accessions developed from qualitative morphological characters

The first group consisted of accession LAB-2; the second group consisted of accession CIS-1; and 54 other accessions into third group. The accession of the closest similarity consists of three groups: accession Ked-2, PRO, and MAD-3; PAS-2, JOM-2, and PON-2; Ked-1, PAS-1, GRE, MAD-2, and LAM, is equal to 100%. Kediri, Probolinggo, Madiun, Pasuruan, Jombang, Ponorogo, Gresik, and Lamongan are city name or area in the same province where 3 group of accession found with 100% similarity. It is assumed that the genetic similarity among accession in the group (Ked-2, PRO, and MAD-3 or PAS-2, JOM-2, and PON-2 or Ked-1, PAS-1, GRE,
MAD-2, and LAM) might have been introduced from the same source or region (Goodarzi et al., 2011).

Each accession in these three groups was obtained in East Java. The three groups met at a distance of 92.26% similarity. Accessions of the most distant resemblance are accession CIB-1 obtained from West Java and accession Ked-2 obtained from East Java 70.01%. While the closest resemblance accession (97.91%) were accession LAB-3 from West Nusa Tenggara and SAL-2 from West Java. These results showed that genetic variation of castor beans in Indonesia and neighboring countries is low, accession from The Philippines and Thailand did not emerge as the most genetically distant with any germplasm from Indonesia, rather the greatest difference is between West Java and East Java. Differences among castor bean germplasm studied from Indonesia, The Philippines, and Thailand has no apparent geographical basis. This is parallel to what Foster et al. (2010) found, that the recent and global spread of only a few castor bean germplasm suggests that this species does not follow typical genetic patterns in plant distributions. It is estimated that all germplasm of castor bean collected were from the same region, as this species was introduced from somewhere in Africa (Weiss 1971; Heyne 1987; Chevallier 2001). Additionally, castor bean is a monotypic plant with wide variation (Shifriss, 1955) so that the variations among this germplasm collected are low.

Genetic variation of the 56 castor bean accessions observed is thought to have emerged due to the influence of seasonal variation (geographic conditions) where each castor bean germplasm was found and observations and measurements made. Shifriss (1955) stated that all castor bean races respond to seasonal variations. In order to improve genetic diversity of castor bean in Indonesia and neighboring countries, it is necessary to carry out domestication of more castor bean germplasm, hybridization (conventional and modern), and mutation, as has been done in cotton breeding (Poehlman and Sleper, 1995). Unfortunately a previous study conducted by Foster et al. (2010) including a wide assessment of SNP variation in castor bean collection worldwide revealed relatively low levels of genetic variation. So, to increase castor bean genetic variation that can support its breeding program, mutation breeding and genetic transformation could be done to obtain new character sources. It is for this reason that worldwide castor bean breeding programs are advanced, such as genetic transformation using Agrobacterium tumefaciens (Sujatha 2005), particle gun (Sailaja 2008), and gene transformation of cry1EC gene (Sujatha et al. 2009).

4. CONCLUSIONS

The 56 castor bean accessions varied based on morphological characters. A dendrogram generated based on qualitative morphological characters showed that, the 56 accessions were classified into three main groups at 72% similarity levels indicating low variability.

5. REFERENCES


Growth and Morphological Characteristics of Acacia Hybrids (Acacia mangium X A. auriculiformis) Observed in Clonal Trial: Early Identification Markers of High Productive Hybrids Tree

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ABSTRACT

*Acacia* hybrids (*Acacia mangium* x *A. auriculiformis*) breeding program in Center for Forest Biotechnology and Tree Improvement was initiated in 1999 through natural hybridization. Artificial hybridization through controlled pollination was then practiced in 2004, in which the parents for crossing were collected from selected plus trees in first-generation (F-1) seedling seed orchards. *Acacia* hybrids seed was then tested in field to observe the growth performance. The purpose of this study is to observe early growth and morphological characteristics of *Acacia* hybrids tested in a clonal trial, and to develop early identification markers of high productive hybrid trees. Forty-four clones of *Acacia* hybrids multiplied through vegetative propagation were tested in the trial in Central Java using incomplete block design, single tree-plot, 20 replications and spacing 3 x 3 m. Observation was done at two years age involving height, diameter, stem volume, and morphological characters of branching and leaf patterns. The results of study showed that significant differences among the *Acacia* hybrid clones were detected in growth traits. Of the 44 clones, stem volume from 15 clones was above the total mean test (> 0.005 m³). The best three hybrids clones exceeded the best performing improved F-2 of pure *A. mangium* by 6-17% indicating the stronger heterosis. The top performance of *Acacia* hybrids clones could be identified with a similar pattern in morphological characteristics of branching and leaf. The implications of these results on early identification of high productive hybrids tree are discussed briefly.

Keywords: *Acacia* hybrids, *Acacia mangium*, *Acacia auriculiformis*, clonal trial, growth, morphological characteristics.

1. INTRODUCTION

*Acacia* hybrid is an out-crossed variety between *Acacia mangium* and *A. auriculiformis*, either naturally or artificially. Superior *Acacia* hybrid has some merit as compared to the pure parents, such as fast growth, straight main stem, light branches, soft bark and resistance to pest and disease (Nikles *et al*. 1998, Kha 2001). In addition, they had better wood properties with higher quality for pulp and paper industry compared to *A. mangium* (Khalid *et al*. 2010, Yahya *et al*. 2010, Rukeya *et al*. 2010, Kha *et al*. 2012, Kato *et al*. 2012). Regarding these features, *Acacia*
hybrids has become a potential alternative species in short of rotation of plantation forest, not only dealing with raw materials for pulp and paper, but also for solid wood industries.

Hybrid vigor is key elements of the high productive hybrid trees and has been one of driving forces in hybridization breeding program. This phenomenon has been well documented in some forest tree species, such as poplar, aspen and pines (Zobel and Talbert, 1984). In tropical tree species, hybridization of eucalypts species is one of the most commonly practiced. With regard to Acacia species, intensive hybridization program has been reported in some countries, such as in Malaysia (Ibrahim, 1993) and Vietnam (Kha, 1999). As of yet, the hybridization of Acacia species has not seen much application in Indonesia, in spite of the fact that the plantation forest program for fast growing species, such as Acacia mangium and Eucalyptus pellita are huge.

As part supporting the huge plantation forest program in Indonesia, Center for Forest Biotechnology and Tree Improvement (CFBTI) has initiated hybridization program for Acacia species in 1999 through establishing natural hybridization plot of A. mangium and Acacia auriculiformis using unimproved trees (Susilowati and Setiadi, 2003). On the way the progressed of first-generation breeding program for A. mangium and A. auriculiformis, in 2004 hybridization breeding garden was established using clones of plus trees selected from the first-generation seed orchard to facilitate artificial hybridization through controlled pollination. Acacia hybrid seed has been produced from several crossing combinations and now they were being tested in field trial to select the Acacia hybrid which having high hybrid vigor (Sunarti, 2008).

Besides of the better growth, early selection of Acacia hybrid would become an essential factor to the success of hybrids clonal propagation before deploying in operational plantation. This is because the aging affects due to maturity would limit the ability of trees to be propagated. Therefore effort to find out a techniques supporting early selection of Acacia hybrid trees is necessary. Considering the background mentioned above, this study was aimed to observe early growth and morphological characteristics of the Acacia hybrids tested in a clonal trial, and to develop early identification markers of high productive hybrid trees.

2. MATERIALS AND METHODS

2.1 Clonal Trial

Acacia hybrid seed were collected from the results of controlled pollination between A. mangium and A. auriculiformis using 22 crossing combinations in hybridization breeding garden (Sunarti, 2011). The four months age of Acacia hybrid seedling was then selected on their growth performance in nursery for clonally multiplication. Amount of 44 selected seedling, hereinafter referred as clone, which was mass propagated through shoot cutting were used as genetic material for field clonal trial.

The experimental design of clonal trial was laid out as Incomplete Block Design with a single tree-plot, twenty replications and spacing of 3 m x 3 m. Out of 44 clones, four controls was also involved in the clonal test for comparison. The controls consisted of two pure species of A. mangium and A. auriculiformis, in which the each species controls were planted using both seedling and cutting. The seed of controls were collected from the current best seed sources: first-generation seedling seed orchard (SSO) of A. auriculiformis and second-generation SSO of A.
mangium. Clonal test was established at Wonogiri, Central Java, 200 km a part of CFBTI site where the crossings has been made. Site and soil descriptions are presented at Table 1 and 2

Table 1: Site description of *Acacia* hybrid clonal trial in Wonogiri, Central Java

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>7º80' South</td>
<td></td>
</tr>
<tr>
<td>Longitude</td>
<td>110º93' East</td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td>141 m a.s.l.</td>
<td></td>
</tr>
<tr>
<td>Annual rain fall</td>
<td>1.645 mm/year</td>
<td></td>
</tr>
<tr>
<td>Dry month – wet month</td>
<td>6 months-6 months</td>
<td></td>
</tr>
<tr>
<td>Soil type</td>
<td>Mediterranean</td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>C (Schmidt and Ferguson)</td>
<td></td>
</tr>
<tr>
<td>Max-min temperature</td>
<td>32ºC-21ºC</td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>±10%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Soil texture and chemical descriptions at 0-20 cm depth in *Acacia* hybrid clonal trial

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand (%)</td>
<td>1.3-7.4</td>
<td>Clay texture</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>16.8-46</td>
<td>-</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>64.9-83.2</td>
<td>-</td>
</tr>
<tr>
<td>Total organic C (Walkley &amp; Black) (%)</td>
<td>1.9-2.01</td>
<td>Low</td>
</tr>
<tr>
<td>Total N (Kjeldahl) (%)</td>
<td>0.19-0.2</td>
<td>Low</td>
</tr>
<tr>
<td>C/N ratio</td>
<td>10-11</td>
<td>Low</td>
</tr>
<tr>
<td>P$_2$O$_5$ tersedia P (Bray 1) (ppm)</td>
<td>3.5-4.9</td>
<td>Very low</td>
</tr>
<tr>
<td>CEC Ca (cmol/kg)</td>
<td>6.28-9.3</td>
<td>Middle</td>
</tr>
<tr>
<td>CEC Mg (cmol/kg)</td>
<td>2.51-3.49</td>
<td>Middle</td>
</tr>
<tr>
<td>CEC K (cmol/kg)</td>
<td>0.16-0.62</td>
<td>Middle</td>
</tr>
<tr>
<td>pH (H$_2$O)</td>
<td>4.8-5.1</td>
<td>Acid</td>
</tr>
<tr>
<td>pH (KCl)</td>
<td>4.4-4.5</td>
<td>Acid</td>
</tr>
</tbody>
</table>

2.2 Measurements and Data Analysis

Measurements of height, diameter at breast height (dbh), and individual stem volume were conducted at two years of age after planting. Individual stem volume was calculated with the volume equation (Inose *et al.*, 1992):
\[ v = 0.000058806 x D^{1.71772} x H^{1.0809} \]  

In case of morphological characteristics observation, they were practiced through the assessment of branching characters and leaf patterns. To observe the leaf patterns, herbarium was made from individual trees in several replications representing all tested clones. Leaf patterns covered of length of leaf (LL), width of leaf (WL), ratio of LL/WL, length of node (LT) and length of petiole (LV).

Analysis of variance was made using individual tree data \( y_{ij} \) with the following linear model:

\[ y_{ij} = \mu + R_i + C_j + e_{ij} \]  

where, \( \mu \), \( R_i \), \( C_j \), \( e_{ij} \) are population mean, the \( i \)th replication effect, the \( j \)th clone effect, and experimental error associated with \( y_{ij} \), respectively.

Phenotypic variances were calculated as the sum of clone variance component \( \sigma_c^2 \) and that of error variance \( \sigma_e^2 \).

Individual ramet repeatability \( h_i^2 \) and clone mean repeatability \( h_c^2 \) were then estimated by:

\[ h_i^2 = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_e^2} \]  

\[ h_c^2 = \frac{\sigma_c^2}{\sigma_c^2 + \frac{\sigma_e^2}{R}} \]  

where, \( R = \) number of replications.

3. RESULTS AND DISCUSSION

3.1 Growth and Genetic Parameters

In general, the Acacia hybrid performed fair in clonal trial. However, in most cases, their growth was less than that of improved pure species parents. The growth the hybrid tested in clonal trial were highly varied from 1.7 m-6.7m for height, 2.34 cm-7.38 cm for dbh and 0.0005 m\(^3\)-0.0122 m\(^3\) for individual stem volume. Corresponding to the average growth of control (pure species of \( A. mangium \) and \( A. auriculiformis \)) were 5.8 m for height, 6.22 cm for dbh and 0.009 m\(^3\) for stem volume. The varied of the hybrids performance observed in the clonal trial might be due to utilizing the untested hybrid seed which was clonally multiplied at seedling stage, despite they was made from controlled pollination hybridization and has been verified using SCAR marker as true Acacia hybrids. Thus, it confirmed that genetic quality of Acacia hybrids seed displayed unstable expression and they tended to perform varies growth. Therefore, once high productive hybrid trees had been selected, they should be clonally propagated for planting in operational plantation.

Highly significant differences \( p<0.0001 \) among the tested clones were detected in the analysis of variance for all traits (Table 3). Individual tree repeatability were generally quite high and comparable for all the three traits: 0.67 for height, 0.48 for dbh and 0.67 for stem volume (Table 4). The high values were also observed in clone mean repeatability: 0.98 for height, 0.95
for dbh and 0.94 for stem volume. The high repeatability, either based on individual tree or clone mean, was stimulated by the wide varies of growth performances. Thus, these results confirmed that selection the clones could be potential for obtaining high productive the hybrid tree.

Table 3: Mean of squares for the three measured traits at two years of age in *Acacia* hybrid clone trial

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>degree of freedom</th>
<th>mean of squares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>height</td>
</tr>
<tr>
<td>Clone</td>
<td>43</td>
<td>26.032 **</td>
</tr>
<tr>
<td>Error</td>
<td>691</td>
<td>0.618</td>
</tr>
</tbody>
</table>

Note: ** significant at level confidence 1%

Table 4: Variance component and repeatability for the three measured traits in *Acacia* hybrid clone trial

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Variance component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>height</td>
</tr>
<tr>
<td>Clone</td>
<td>1.278</td>
</tr>
<tr>
<td>Error</td>
<td>0.618</td>
</tr>
<tr>
<td>Clone repeatability</td>
<td>0.98</td>
</tr>
<tr>
<td>Individual repeatability</td>
<td>0.67</td>
</tr>
</tbody>
</table>

There were three clones showed an outstanding growth than controls, and fifteen clones were above the total clones mean test. The superiority of the best tree clones over controls were approximately 6% for height, 6% for dbh and 17% for stem volume, which might indicate a stronger heterosis. Their superiorities were much smaller compared to other study reported in Vietnam by Kha (2000) where *Acacia* hybrid was more than 100 % better than control. There are two possible reasons for this discrepancy. First, it should be noted that controls used in present study were planted using high genetically improved seed from the best second generation seedling seed orchard of *A. mangium* and first-generation seedling seed orchard of *A. auriculiformis*. Thus, the superiority of *Acacia* hybrids over these pure species parents would reflect the high heterosis of the hybrids. Secondly, at the same age the growth of *A. mangium* plantation in Indonesia was at least three times greater than that in Vietnam. In these cases, the amount of improvement from selected clones here would be considerable for increasing current plantation productivity. Moreover, the growth performance of the *Acacia* hybrid in this study was still observed at younger age (2 years), and it is expected to be better as the tree getting older.
3.2 Morphological Characteristics

Regarding the varied performance of the *Acacia* hybrid clones as described in preceding paragraph, thus morphological characters observations were started through classifying the tree into three classes of multi-stem: 1) multi-stem at bellow 1/3 total height, 2) multi-stem at between 1/3 – 2/3 total height, 3) multi-stem at above 2/3 total height. In order to know a relationship between growth and morphological characters, the three classed of multi-stem clones were then converted to the averages stem volume of clones. As a result, the three classes were equal to three classes of stem volume: less than 0.004 m$^3$ for class 1, between 0.004 m$^3$ to 0.007 m$^3$ for class 2, and above 0.007 m$^3$ for class 3. There were 20 clones in class 1, 14 clones in class 2, and 10 clones in class 3 (Table 5).

<table>
<thead>
<tr>
<th>Multi-stem classes</th>
<th>Stem volume classes (m$^3$)</th>
<th>Number of clones</th>
<th>Mean stem volume (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 0.004</td>
<td>20</td>
<td>0.0017 c</td>
</tr>
<tr>
<td>2</td>
<td>0.004-0.007</td>
<td>14</td>
<td>0.0048 b</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 0.007</td>
<td>10</td>
<td>0.0083 a</td>
</tr>
</tbody>
</table>

Table 5: Classes based on multi-stem and stem volume followed by number of clones

Note: mean values with different letter are significantly different at level 1%

As shown at Table 5, multi-stem significantly affected the stem volume of *Acacia* hybrids. It indicated that clones in higher multi-stem class would show better growth than that in lower class. Most of the clone in lower multi-stem class tended to perform a shrubby, and it was more evident for the clones particularly in class 1. Another interesting fact from this result is that 25% of tested clones, with averaged stem volume of 0.0083 m$^3$, showed evidently better growth above the total clones mean test of 0.005 m$^3$. This result implied that multi-stem character should be used as first criteria for selecting the high productive *Acacia* hybrids.

Other possible morphological characters that might be useful to early identification of high productive *Acacia* hybrid are leaf patterns. Characters such as length and width of leaf, length of petiole and length of nodes are some of characters commonly used for identifying the differences of species or varieties. In this present study, those characters would be used to identify of high productive *Acacia* hybrids. There are two reasons to use these characters in this purpose study. First, as discussed in preceding paragraph that the *Acacia* hybrid clones showed wide varies performance in growth, and it would be useful to classify quality of the growth based on their morphological characters. Secondly, once high productive hybrid tree was selected, they would be mass clonally propagated for operational plantation. However, the success of clonal propagation would be much reduced as the tree getting older due to ageing effect. In this case, early selection of the hybrid trees is necessary, and leaf morphological characters would be one possible markers to identify high productive hybrid trees from younger age.
Correlation between the stem volume and the five leaf patterns using pooled data analysis across the three classes were weak (Figure 1A). Analysis on the respective stem volume classes was varied from weak to moderate (Figure 1B, 1C and 1D). The correlations were generally stronger as the increases of stem volume classes as indicated by Figure 1B where clones having stem volume above 0.007 m³ showed better correlation with the five leaf patterns than those with stem volume bellow 0.007 m³ (Figure 1C and 1D). Clones which having poorest stem volume showed the lowest correlation. Among the five leaf patterns in class 3 (>0.007 m³), length of petiole, length of node and width of leaf showed better positive correlation with stem volume. It should be noted here that stem volume classes were converted from multi stem classes. Therefore, these three leaf characters might be potential to be used as early identification markers of high productive *Acacia* hybrid as long as classifying of the tree based on the multi stem is practiced first. These leaf characters could not be applied without preliminary selection based on multi stem character, and they could be effective for high quality of multi stem only.

4. CONCLUSIONS

There were highly significant differences among the *Acacia* hybrid clones tested in clonal trial. Of the 44 clones, fifteen clones showed stem volume above the total mean test (0.005 m³). The best three hybrids clones showed stronger heterosis where the stem volume exceeded the best performing improved F-2 of pure *A. mangium* by 6%-17%. Three morphological characters of leaf patterns: length of petiole, length of node and width of leaf, might be potential to be used as early identification markers of high productive *Acacia* hybrid, and it could be effective for the trees which having high quality of multi stem character only.
ACKNOWLEDGMENTS

We would like to express our gratitude to The *Acacia* and *Eucalyptus* Research Team for establishing, maintaining and measuring the plot. We also acknowledge the contribution of Molecular Laboratory team at CFBTI.

5. REFERENCES


Zobel, B and Talbert, J (1984): *Applied Forest Tree Improvement.* John Willey and Sons, USA.
Genetic Variation on Early Growth of Jabon (*Anthocepalus* spp.)
Observed in First Generation Seedling Seed Orchard

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ABSTRACT

Considering the fast growth, acceptable the wood properties and adaptable to the site planting, two species of jabon: jabon putih (Anthocephalus cadamba) and jabon merah (Anthocephalus macrophyllus), showed great potential as alternative species for pulpwood. Breeding program of these species has been initiated by the Center for Forest Biotechnology and Tree Improvement through exploring genetic materials which was then followed by establishing first-generation seedling seed orchard (SSO). The purpose of this study was to evaluate the genetic variation on early growth of jabon putih and jabon merah which is observed in first-generation SSO. The orchards of the two species were established in Central Java and East Java. Measurements were conducted at two years age for Jabon Putih and at one year for Jabon merah, involving tree height, diameter, and stem form. The result of study showed that significant difference among tested families was detected in the orchards for all traits of the both species. For jabon putih, the average of height, diameter and stem form were 4 m, 5.2 cm and 2.6, respectively with family heritability were 0.3 for height, 0.4 for diameter and 0.15 for stem form. In case of jabon merah, the average height, diameter and stem form was 3.8 m, 5 cm and 2.6, respectively with family heritability were 0.6 for height, 0.6 for diameter and 0.09 for stem form. High genetic variation on growth traits in the both species indicated that high potential for genetic improvement could be achieved through selection in the seedling seed orchard.

Keywords: Jabon, Anthocephalus cadamba, Anthocephalus macrophyllus, genetic variation, pulpwood, alternative species, growth

1. INTRODUCTION

The wood pulp industry in Indonesia is dependent on large monoculture of Acacia mangium and Eucalyptus pellita plantation. Pathologically, ecologically, environmentally and other issues usually undesirable and need it the alternative species for back up. Considering the fast in growth, acceptable wood properties and adaptable to the site of plantation, two species of jabon: jabon putih (Anthocephalus cadamba) and jabon merah (Anthocephalus macrophyllus), showed the great potential as alternative species for pulpwood.

Jabon (Anthocephalus spp.), one of Indonesia native species, have good potency and possibilities for that purpose. Not only fast growing but also adaptable for wide range plantation area until 1000 m asl. The wood density was about 0.44 – 0.51, fiber length 1.75 – 1.91 mm (Rahmayanti et al., 2009) and so was another pulp properties have categorized the wood in first class quality of pulpwood alternative species. Jabon has also suitable for use in wide range utilities (Ruhendi, 2009).
Tree improvement program for Jabon in Center for Forest Biotechnology and Tree Improvement (CFBTI) was started in 2011 - 2012. The program was aimed to evaluate the growth and stand volume productivity as part of a breeding program for alternative pulpwod species. Breeding program of these species has been initiated by CFBTI through exploring genetic materials which was then followed by establishing first-generation seedling seed orchard (SSO).

The purpose of this study was to evaluate the genetic variation on early growth of jabon putih and jabon merah which is observed in first-generation SSO. The orchards of the two species were established in Central Java and East Java. The results of this study are expected to add the information for improving breeding strategies and deployment its materials of Jabon (*Anthocephalus* spp.) for the plantation in the future.

2. MATERIALS AND METHODS

2.1. Seed Collection

The seed of jabon putih (*A. cadamba*) collected through exploring genetic materials from natural stand in Java in 2010 and jabon merah (*A. macrophyllus*) collected in South East Sulawesi in 2011. Seed were sown in and transplanted into polybag (5 x 10 x 15 cm) containing topsoil as potting medium.

2.2. The Trial Design and Measurement

The progeny trials analyzed in this study are the first generation (F1) seedling seed orchard of jabon putih (*A. cadamba*) and jabon merah (*A. macrophyllus*). The trials were established in Wonogiri, Central Java. The progeny trial of *A. cadamba* established in 2011 with 75 families, 4 trees plot, spacing 3 x 2 m and 10 blocks of replications. The progeny trial of *A. macrophyllus* established in 2012 with 55 families, 4 trees plot, spacing 3 x 2 m and 8 blocks of replications. Both of the trials built in the same design: completely randomized block (RCBD). Measurement was conducted at at two years age for *A. cadamba* and at one year for *A. macrophyllus*, involving tree height, diameter, and stem form. Detail information of both trials is shown at Table 1 below:

<table>
<thead>
<tr>
<th>Item</th>
<th><em>A. cadamba</em></th>
<th><em>A. macrophyllus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope (%)</td>
<td>10</td>
<td>10-20</td>
</tr>
<tr>
<td>Previous vegetation</td>
<td>scrub</td>
<td>cultivated</td>
</tr>
<tr>
<td>No. Of replicates</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Plot size</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Spacing</td>
<td>3 x 2 m</td>
<td>4 x 2 m</td>
</tr>
</tbody>
</table>

Table 1: Site characteristic and trial design.
2.3. Methods of Data Analysis

2.3.1. Analysis of variance

The data were then analysed using analyses of variance based on the linear model as follows (Matheson and Raymond, 1984; Johson, 1992) (Equation 1):

\[ Y_{ij} = \mu + R_i + F_j + E_{ij} \]

(1)

where:
- \( Y_{ij} \): plot mean of the \( j \)-th family in the \( i \)-th replication
- \( \mu \): mean of population
- \( R_i \): an effect of the \( i \)-th replication
- \( F_j \): an effect of the \( j \)-th family
- \( E_{ij} \): error associated with \( Y_{ij} \)

2.3.2. Heritability values

Family heritability calculated by using the formula Wright (1976); Zobel and Talbert (1984) as shown following equation (Equation 2):

\[ h^2_f = \frac{\sigma^2_f}{\sigma^2_e/nb + \sigma^2_{fb}/n + \sigma^2_f} = \frac{\sigma^2_f}{[MS_f / coef. \sigma^2_f]} \]

(2)

where:
- \( h^2_f \): heritability of family
- \( \sigma^2_f \): variance component of family
- \( \sigma^2_{fl} \): variance component of family - location interaction
- \( \sigma^2_{fb} \): variance component of family - block interaction
- \( \sigma^2_e \): error variance component
- \( l \): number of location
- \( b \): number of block per location
- \( n \): number of tree per plot
- \( MS_f \): mean square of family
- \( coef. \sigma^2_f \): coefficient of variance component family

2.3.3. Genetic correlation

Genetic correlations of each trait (\( r_{ij} \)) were calculated from estimates of additive genetic variance and covariance according to Falconer (1981). Phenotypic correlations were estimated as simple correlation coefficient (Falconer, 1981).

3. RESULTS AND DISCUSSION

3.1. Growth

Mean tree height, diameter and stem form are shown at Table 2. The growth was generally good for jabon putih and very good for jabon merah. For jabon putih, the average of height, diameter and stem form were 4 m, 5.2 cm and 2.6, respectively. The growth of jabon putih in that site of SSO (Wonogiri) slower than that planted in another location. In Kediri, East Java, with the same genetic material the growth of jabon putih in the SSO at 2 years old were 5.62 m, 7.94 cm and 2.6 for the average of height, diameter and stem form respectively (Setyaji, 2013).
However, the growth of jabon putih was better than *Acacia mangium* which planted on the same area. Leksono *et al.* (2005) reported the growth of *A. mangium* on genetic gain trial planted near to the location were 1.74 m and 2.03 cm for height and diameter at 1 year old and 4.9 m and 4.94 cm at 2 years old. The differences of growth among SSO jabon putih had a highly correlation with the quality of site. In Wonogiri, the SSO established in the site with scrub as previous vegetation without any cultivation activities or agroforestry. In the opposite of SSO in Kediri the site intensively cultivated by many agroforestry activities. Accordingly, it was reasonable to claim that the site of Kediri is better and suitable for jabon putih to grow.

In case of jabon merah, the growth at 1 year old much faster with the average of height, diameter and stem form were 3.4 m, 5 cm and 2.6 respectively. It was so close to jabon putih at 2 years old and most highly than *A. mangium* and so does *Falcataria moluccana* at the same age. Hadiyan (2010) reported the growth of *F. moluccana* planted on SSO F1 Cikampek were about 2.4 m for height and 4 cm for diameter.

Table 2: Estimation of variance component and family heritability by single and across test

<table>
<thead>
<tr>
<th>Traits</th>
<th>SSO F-1</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>A. cadamba</em></td>
<td><em>A. macrophyllus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age (years):</strong></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Height:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean (m)</td>
<td>3,914</td>
<td>3,379</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family variance component ($\sigma^2$)</td>
<td>0,05476*</td>
<td>0,0896**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family heritability ($h^2$)</td>
<td>0,32</td>
<td>0,64</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diameter (dbh):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean (cm)</td>
<td>5,205</td>
<td>4,966</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family variance component ($\sigma^2$)</td>
<td>0,1598**</td>
<td>0,1488**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family heritability ($h^2$)</td>
<td>0,38</td>
<td>0,59</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stem form (range : 1 – 3):</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>2,5</td>
<td>2,63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family variance component ($\sigma^2$)</td>
<td>0,0092*</td>
<td>0,0023*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family heritability ($h^2$)</td>
<td>0,15</td>
<td>0,36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** : significant at 1% ,  * : significant at 5%

### 3.2. Heritability Estimates

The Table 2 showed that height, diameter and stem form for both trial were significant family effect. The family heritability of jabon putih were 0.32; 0.38 and 0.15 respectively for height, diameter and stem form. In case of jabon merah, family heritability was 0.6 for height, 0.65 for diameter and 0.09 for stem form. These heritability estimates were calculated for a single site and therefore maybe biased upwards by presence of genotype-environment interactions. Published data on heritability estimates of jabon putih and jabon merah are still scarce.

### 3.3. Genetic and Phenotypic Correlation

According to Table 3, height and diameter for both jabon putih and jabon merah had strong, positive genetic correlation at ages 2 and 1 year old. Phenotypic correlations between these traits followed the corresponding genetic correlation but marginally lowest than its genetic correlation. High correlation between height and diameter at age 2 years old have been
recorded in other species e.g *Eucalyptus pellita* 0.89 – 0.97 (Hardiyanto, 2003) and also *E. globulus* 0.55 (Volker *et al.*, 1990 in Hardiyanto, 2003).

Table 3: Genotypic an phenotypic correlation

<table>
<thead>
<tr>
<th>Correlation of traits</th>
<th>Jabon Putih</th>
<th>Jabon merah</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Genotypic</td>
<td>Phenotypic</td>
</tr>
<tr>
<td>Height – Diameter</td>
<td>0.95</td>
<td>0.05</td>
</tr>
<tr>
<td>Height - Stem form</td>
<td>-0.10</td>
<td>-0.003</td>
</tr>
<tr>
<td>Diameter - Stem form</td>
<td>0.22</td>
<td>0.008</td>
</tr>
</tbody>
</table>

High genetic correlation between height and diameter indicates simultaneous selection of these traits is possible, and selection for diameter, the trait easier to measure, will bring a substantial positive response for height (Hardiyanto, 2003).

4. CONCLUSIONS

The result of study showed that significant difference among tested families was detected in the orchards for all traits of the both species. For jabon putih, the average of height, diameter and stem form were 4 m, 5.2 cm and 2.5, respectively with family heritability were 0.32 for height, 0.38 for diameter and 0.15 for stem form. In case jabon merah, the average of height, diameter and stem form was 3.4 m, 5 cm and 2.6, respectively with family heritability were 0.6 for height, 0.65 for diameter and 0.09 for stem form. High genetic variation on growth traits in the both species indicated that high potential for genetic improvement could be achieved through selection in the seedling seed orchard.

ACKNOWLEDGEMENT

The author would like to thank to The Acacia - Eucalyptus - Jabon Improvement Team (“Acapella Jambo” Team) CFBTI Jogjakarta.

5. REFERENCES


Diversity of Bats in Coal Mining Rehabilitation Site

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Diversity of Bats in Coal Mining Rehabilitation Site

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ABSTRACT
The coal mining rehabilitation technique aims to generate quickly and naturally succession in rehabilitation area. Bats have important roles in succession process, as seeds dispersal and plants pollinator therefore the presence of these animals in the coal mining rehabilitation area is very important. The purpose of this study was to measure the bats diversity in a coal mining rehabilitation area. This research was done by using mistnets installed at the three different age levels of rehabilitation area. The results showed that there were 5 species of bats belong to 3 families. Generally, the diversity indices (H') of bat at the study site was 1,57. The dominant species were fruit bats species namely Short-nosed Fruit Bat (Cynopterus brachyotis Müller), Dusky Fruit Bat (Penthetor lucasi Dobson) and Common Dawn Bat (Eonycteris spelaea Dobson). Frequency of catched bats by mistnets increased by the increase of the age of the plant in the rehabilitation area. The highest catched bats frequency occurred in the rehabilitation area whose the age of its plant was 8 years.

Keywords: Bat, diversity, plant rehabilitation, coal mining, mist net

1. INTRODUCTION
Rehabilitation techniques on coal mining areas have been done in various ways; applying plant species selection method (Saridan, 2009), microorganisms utilization (Naemah, 2009), and soil improvement. The indicator of successful rehabilitation is the return of the forest functions as a habitat for wildlife. The presence of vegetation planted or growed naturally in coal mining reclamation area might invites animals and then these animals are expected to be the agent or the carrier of new plant species to grow naturally (Boer, 2009). Various types of mammal both small mammals and large mammals have an important role as a seed dispersal which are part of the process of regeneration of many plant species.

Bats are categorized in the Chiroptera order and the only mammal that fly. The order is divided into 19 families, 175 genera, and 942 species (Nowak & Paradiso, 1983). At least 205 species of bats found in Indonesia (Suyanto, 2001), 95 species of them are founded in Borneo (Payne et al., 2000). Bats are classified into two sub-orders that based on dietary variations namely, Megachiroptera (fruit bats) and Microchiroptera (insect eating bats). Generally, fruit bat morphology is characterized by large eyes, dog-like snout, and claw on 2nd digit. Meanwhile feature of insects eating bats are small eyes, nose often complex, and no claw on 2nd digit.

Bats play key roles in forest ecosystems. They control insects and they are important pollinators, seed dispersal and contributo the regeneration of highly deforested habitats (MacKinnon et al., 1996; Dumont & O’Neal, 2004; García-Morales et al., 2012). Some species of bats may useful for monitoring the success of restoration (Calvert & Neiswenter, 2012). Bats disperse seeds for both pioneer species and late successional stages species (García-Morales et al., 2012), and also they play an important role for the initial stages of regeneration in forest ecosystem.

The existence of bats in coal mining rehabilitation area has an important role in accelerating the process of natural succession. Therefore, the purposes of the study were to find out the species and the presence of bats in the coal mining rehabilitation area.
2. METHODS

2.1 Time and Site

The research was conducted in September 2012 at coal mining rehabilitation area of PT. Kideco Jaya Agung, which located at the Paser District, East Kalimantan Province, Indonesia (S0°51'-1°58'E115°50'-115°53').

2.2 Equipments and Materials

Equipment for this research i.e. mist nets, digital caliper, ruler, bat pockets, DSLR camera, and field guides of bat (Payne et al., 2000; Suyanto, 2001; Struebig & Sujarwo, 2006). Materials in this research were sugar fluid and alcohol 70%.

2.3 Sampling Methods

Three location were chosen based on the age of the plant in several rehabilitation area, which were:

- Site A: A year-old. Sengon buto (Enterolobium cyclocarpum), planted in 2011 with spacing distance of 3 m x 3 m. The location was close to natural forests and limestone cliffs.
- Site B: Four year-old. Sengon laut (Paraserianthes falcataria) and Akasia (Acacia mangium), planted in 2008 with spacing distances of 3 m x 3 m. Average height and diameter of plant were 12 m and 17 cm, respectively.
- Site C: Eight year-old. Planting process of Sengon laut (Paraserianthes falcataria) was began in 2004 with spacing 4 m x 4 m. Average height and diameter of plant were 17 m and 30 cm, respectively.

Tens mist nets (height 2.5 m, length 9–14 m, and mesh size 16 mm x 16 mm) were set-up to capture bats. In each site was installed with 6-8 mistnets for 3-4 nights. One net on a night calculated as one net-night. In site A, B, and C, we set 24, 36, and 22 nets-nights, respectively. The number of mistnets installed at each location was different depending on field conditions.

Each captured bat was removed carefully from the net and placed individually in a cotton bag. Then, Identification process were conducted based on external characters using a key based on Struebig & Sujarwo (2006). Morphometric measurements (weight, forearm length, ear height, hind-foot length, tile length, wing length). The following external measurements were taken using a digital caliper to the nearest 0.01 mm. Liquid sugar was given to keep fit the condition of bats before measurement. The bats were released soon immediately after the measurement process.

2.4 Data Analysis

The bats diversity was calculated by employing Shannon-Wiener Index (Krebs, 1989):

\[
H' = \sum_{i=1}^{s} (p_i)(\log_2 p_i)
\]

\(H'\) = Index of species diversity
\(s\) = Number of species
\(p_i\) = Proportion of total sample belonging to \(i^{th}\) species
3. RESULTS AND DISCUSSION

3.1 Bats Description

We had captured 68 animals that belong to 3 familys, 5generas, and 5 species. Morfometric informations were presented at Table 1:

<table>
<thead>
<tr>
<th>No</th>
<th>Species</th>
<th>Forearm length (mm)</th>
<th>Body mass (gr)</th>
<th>Tibia length (mm)</th>
<th>Tail length (mm)</th>
<th>Ear length (mm)</th>
<th>Wing length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E. spelaea</td>
<td>64.00±2.73</td>
<td>45.88±6.44</td>
<td>15.17±1.31</td>
<td>12.15±3.47</td>
<td>15.48±1.73</td>
<td>426.18±23.35</td>
</tr>
<tr>
<td></td>
<td>N*</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>C. brachyotis</td>
<td>64.18±1.89</td>
<td>32.45±2.84</td>
<td>12.23±1.68</td>
<td>6.13±3.14</td>
<td>14.82±1.85</td>
<td>392.42±69.48</td>
</tr>
<tr>
<td></td>
<td>N*</td>
<td>33</td>
<td>31</td>
<td>34</td>
<td>29</td>
<td>34</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>P. lucasi</td>
<td>65.11±1.57</td>
<td>41.00±3.46</td>
<td>12.55±0.81</td>
<td>4.49±3.17</td>
<td>15.60±1.82</td>
<td>422.78±10.64</td>
</tr>
<tr>
<td></td>
<td>N*</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>H. cervinus</td>
<td>46.45</td>
<td>8.00</td>
<td>6.33</td>
<td>16.19</td>
<td>11.65</td>
<td>nd</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>nd</td>
</tr>
<tr>
<td>5</td>
<td>R. creaghi</td>
<td>50.58±0.10</td>
<td>10±1.41</td>
<td>7.25±1.00</td>
<td>18±1.5</td>
<td>18.19±1.26</td>
<td>322.5±3.54</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Remark: nd = no data
N = number of animal
* Some of bats was identified but getting loose before measurement

Detailed description of bat captured in research site:

**Short-nosed Fruit Bat** (*Cynopterus brachyotis* Müller)

Famili: *Pteropodidae*

**Distribution:** Sri Lanka, Andaman and Nicobar Islands, southern Burma, Thailand, southern China, Indo-China, Philippines, Malaysia, and Indonesia (Kalimantan, Sumatera, Jawa, Bali, Maluku)(Nowak & Paradiso, 1983; Suyanto, 2001).

**Descriptions:** Claw present on 2nd finger, short muzzle, snout like-dog, large eye, simple ears, two pair of lower incisors, wing bones and ears hairless with white edge.

**Ecology and behavior:** Habitat in coastal, urban, agricultural, riverine, and all type of forest up to 1500 m a.s.l. (Boon & Corlett 1990). It typically roosts in small groups in trees, under banana leaves, palm fronds and man-made structures (Mohd-Azlan et al., 2010). The species feeding is on fruits, flowers and leaf fractions (Tan et al., 1998).

**Dusky Fruit Bat** (*Penthetor lucasi* Dobson)

Famili: *Pteropodidae*

**Distribution:** Sumatera, Kalimantan, Riau Archipelago, Malaysia, Singapura (Payne et al., 2000; Suyanto, 2001).

**Descriptions:** Claw present on 2nd digit, snout like-dog, large eye, simple ears, one pair of lower incisors.

**Ecology and behavior:** Distributed in lowland, hill forests up to 600 m a.s.l., and normally roosting in cave, rock shelter, or crannies between large bounders (Nowak & Paradiso, 1983;
Payne et al., 2000). The animal feeds at the nearest fruit plantation immediately after dusk and fruit are carried back to the cave which are eaten (Nowak & Paradiso, 1983).

**Lesser Dawn Bat** (*Eonycteris spelaea* Dobson)

**Family:** Pteropodidae

**Distribution:** North India, Myanmar, Thailand, Indochina, Malaysia, Filipina, Greater Sundas (Sumatra, Java, Kalimantan and Sulawesi) and Lesser Sundas (Bali to Timor) (Nowak & Paradiso, 1983; Suyanto, 2001; Maharadatunkamsi et al., 2003).

**Descriptions:** No claw on 2nd digit, snout like-dog, large eye, simple ears, short hairs, long tail, has an enlarged external gland lateral to the anus, long tongue and slender for picking up nectar and pollen.

**Ecology and behavior:** Known as nectar-feeders that plays an important role as a pollinator. Colonies of *E. spelaea* range from a few dozen individuals to tens of thousands (Nowak & Paradiso, 1983) and are active mainly during the night to search for prey. The animals usually roost in the total darkness of caves and occur in a variety of habitat, including forest, cultivated areas, boulders, and houses (Nowak & Paradiso, 1983; Payne et al., 2000; Struebig et al., 2012), however Suyanto and Struebig (2007) did not record this species in our cave surveys in Sangkulirang limestone karst formations.

**Fawn roundleaf bat** (*Hipposideros cervinus* Gould)

**Family:** Hipposideridae

**Distribution:** Sumatera, Kalimantan, Sulawesi, Kangean Island, Bacan Island, Kai Island, Papua Nugini, Solomon, Malaysia, Singapura, Filipina, and Australia (Suyanto, 2001).

**Descriptions:** The muzzle has an elaborate leaf consists of an anterior horseshoe-shaped part and an erect transverse leaf and is divided into four ceel.

**Ecology and behavior:** This species has been recorded in primary lowland forest with elevation at least 700 m a.s.l. (Esselstyn et al., 2004), secondary tropical moist forest, open forest, caves (especially large caves), abandoned mines and in hollow trees (Sorba et al., 2008). The colonies reach up to 300,000 individuals (Struebig et al., 2012) and known to forage on small insects in narrow-spaces, clutter, and forest understory (Payne et al., 2000; Khan et al., 2008; Struebig et al., 2012).

**Creagh’s horseshoe bat** (*Rhinolophus creaghi* Thomas)

**Family:** Rhinolophidae

**Distribution:** Kalimantan, Sabah, Java, Timor Island (Suyanto, 2001).

**Descriptions:** The bat has a peculiar with nose-leaf expansion of the skin surrounding the nostrils (consists to horseshoe shaped, sella, and lancet). Conical tuft of hairs replace of connecting process.

**Ecology and behavior:** Insectivorous with foraging in forest-interior and commonly roosting in caves, boulders, and houses (Kobayashi et al., 1980; Struebig et al., 2012).

### 3.2 Diversity

Generally, the diversity indices (H’) of bats at the study site was 1.57. This result was lesser than bat diversity in secondary forest (Atmoko et al., 2013), undisturbed forest (Medelline et al., 2000), and forest fragment (Calouro et al., 2010) that were 3.60, 2.50, and 2.09, respectively, but this diversity indices was greater than that in old rubber plantation, 1.08 (Nugroho et al., 2007). The percentage of bats species in study site was presented in Figure 1.
Figure 1. The percentage of bats species in rehabilitation area of PT. Kideco Jaya Agung

Ninety-six percent of bats was dominated by fruit bats in study site. The species were Lesser Dog-faced Fruit Bat (*Cynopterus brachyotis*), Common Dawn Bat (*Eonycteris spelaea*), and Dusky Fruit Bat (*Penthetor lucasi*). Fruit bats abundance indicates that these bats were adaptive to the environmental conditions. Frugivorous bats can tolerate to anthropogenic disturbances so that the number of bats was abundant at both places; modified and undisturbed habitats (García-Morales *et al.*, 2012). Generally, three significant roles of bats for the plant are as pollinators, as seed dispersers and pollinators at once; seed dispersers (Soegiharto *et al.*, 2010). A Study by García-Morales *et al.* (2012) showed the bats dispersed the seeds of nine pioneer species among semi-deciduous, evergreen, and secondary forests in Mexico.

Pioneer plant species is important for the initial stages of regeneration and it contributes to the regeneration of habitats. García-Morales *et al.* (2012) summarized for several reasons why the frugivorous bats are important seed dispersers in tropical regions: i) They can cover a considerable distance during flight, ii) They may treat seeds inside their guts while they are in transit, iii) they are adapted to forage in different vegetation types and successional stages, and iv) while in flight they defecate, they often drop seeds in sites suitable for germination and establishment.

*Cynopterus brachyotis* plays an important role in the maintenance of species richness of tropical forest. Study by Vanitharani *et al.* (2011) in Kalakad Mundanthurai Tiger Reserve, India reported that at least 26 tropical plants species for their pollination (18 species), seed dispersal (5 species), and both pollination and seed dispersal (3 species) were dependent on *C. brachyotis*. Meanwhile, in Borneo this species consumed fruits and seeds from 24 plant species, consisted of Actinidiaceae, Annonaceae, Arecaeaceae, Burseraceae, Clusiaceae, Dipterocarpaceae, Ebenaceae, Euphorbiaceae, Gnetaceae, Lauraceae, Moraceae, Myrtaceae, Oxalidaceae, Sapotaceae, Theaceae, and four species unidentified (Mohd-Azlan *et al.*, 2010).
C. Bats Captured

The frequency of bats caught at the old-stage of reclamation area was higher than that at the younger-stage reclamation area. Both the number of individuals and diversity indices were different. The number of bats captured in coal mining rehabilitation was presented in Table 2.

<table>
<thead>
<tr>
<th>Age of plant rehabilitation</th>
<th>Nets-nights</th>
<th>Species captured</th>
<th>Individuals captured</th>
<th>H’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A (1 year old)</td>
<td>24</td>
<td>2</td>
<td>0.08</td>
<td>8</td>
</tr>
<tr>
<td>Site B (4 year old)</td>
<td>36</td>
<td>3</td>
<td>0.08</td>
<td>27</td>
</tr>
<tr>
<td>Site C (8 year old)</td>
<td>22</td>
<td>4</td>
<td>0.18</td>
<td>33</td>
</tr>
</tbody>
</table>

In the site A, the plant was relatively small, with a height of about 2 meters. This condition has caused that the food resources of the bats was limited. At the 8 year old reclamation area (Site C), the height of the plant reached of about 10 meters, making more available for bats in form of food resources, either insects or fruits. Moreover, site C provided the quantity and suitability of roosting sites. The results of study by Smith and Gehrt (2010) reported that the bats positively respond to some forms of woodland restoration in urban landscapes.

Two and eighteen individuals of Rhinolophus creaghi and Eonycteris spelaea, respectively were captured only on the site C, while a Hipposideros cervinus was captured in site B. Hipposideros cervinus was very rare in this study site, but this species is commonly founded in lowland dipterocarp forests with a mixture of primary and old secondary forest (Mohd-Azlan et al., 2008; Tingga et al., 2012). Based on the results of the study, the species-specific responses to vegetation were different (Thies & Kalko. 2004), so the further study needs to be done. In addition, bats can be used as biological indicator for the success of a forest rehabilitation process. Study by Calvert & Neiswenter (2012) reported the arizonomyotis (Myotis occultus) and western red bat (Lasiurus blossevillii) may prove useful for justifying restoration and monitoring the success of restoration in southwestern riparian habitats. Furthermore, this study revealed that the presence of western red bats at restoration areas was detected within 3–5 years after planting, which offers relatively quick feedback on use of habitats by this species.

Leaf damage by herbivorous insects has an adversely effect to the growth and survival of rehabilitation plants in early stage Study by Morrison & Lindell (2012) explained that birds and bats play an important role as a predator in restoration area by reducing herbivorous insects and their damaging effects to planted trees. So, restoration should included efforts to attract and provide suitable habitat for birds and bats to support the success of restoration efforts. Smith and Gehrt (2009) suggest that a combination of restoration methods may be the most appropriate approach for managing bats. This method related to prescribed burning, invasive species removal, and selective thinning of trees.

4. CONCLUSIONS

1. Fruit bats dominated in the coal mining reclamation area, they have important roles in succession process,
2. Diversity of the bats at the old-stage reclamation area was higher than that of the young-stage,
3. Presence of bats may can be use as indicator to success of natural regeneration in coal mining reclamation area.
ACKNOWLEDGEMENTS

We send our gratitude to Dr. Nur Sumedi, the Head of Balitek KSDA for his support to this study. We also would like to thank Warsidi (Balitek KSDA) and Arbainsyah (staff of PT. Kideco Jaya Agung) for their help during the field work.

5. REFERENCES


Growth Variation of Pulai (*Alstonia* sp.) at Age Six Years in an *Ex-situ* Conservation Area in Gunung Kidul, Yogyakarta

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ABSTRACT

Pulai (Alstonia sp) collected from six populations in Indonesia. One of them is from West Sumatera and five others from eastern Indonesia viz West Nusa Tenggara, Timor Tengah Selatan (TTS), Bali, South Sulawesi and Kupang. They were planted in an ex situ conservation area in Petak 93 Playen Gunung Kidul. At the age of six years, their survival, total height, diameter at breast height (DBH) and volume were measured. The data were analyzed using analysis of variance (ANOVA) and Duncan’s Multiple Rate test. High survival was observed for all populations (74.5% in average). High correlation coefficients among the characters indicated a close association with each other. Pulai from West Sumatera had the best growth performance; West Nusa Tenggara, TTS, Bali and South Sulawesi were intermediate; while Kupang was the worst. Growth was more influenced by climate type than the geographical position of the populations.

Keywords: Pulai (Alstonia spp), six populations, 6 years old, growth variation

1. INTRODUCTION

Height and diameter are considered reliable parameters for evaluating the success of species and populations (Ginwal and Mandal 2004). For example, significant differences in the total height of 11 provenances of Eucalyptus tereticornis were found at ages three and six years (Otegbeye 1990) and in height, diameter at breast height (DBH), number of branches and field survival in 19 provenances of Acacia nilotica Wild. ex Del (Ginwal and Mandal 2004). Climate and geographical position may also influence growth performance of a species. For Norway spruce (Picea abies (L.) Karst.), growth was generally more weakly correlated with precipitation than with temperature (Makinen et al., 2000); the limiting effect of low temperatures was more significant at northern and high-altitude sites, while the importance of precipitation increased in the south and at low altitudes in (Makinen et al., 2002). Pinus sylvestris from populations in Baltic countries, Bielorussia and Ukraine had superior height growth than those from other European locations (Shutyae and Giertych 1997).

Pulai (Alstonia spp.) that belong to the family Apocynaceae are widely distributed from tropical West Africa to the Marquesas in the Eastern Pacific and from the Himalayas to New South Wales in Australia (Sutisna et al., 1998). Its timber is used for construction, furniture and paneling, and also toys, drawing boards, match sticks, plywood, packing boxes and lattices (Subasinghe 2010). Moreover, the bark, leaves, flowers and roots have been used in traditional medicine. Its pharmacological properties are linked to alkaloids like ditamine, echitamine that have been used to treat diseases such as diarrhea, beri-beri and malaria (Pratyush et al., 2011).

Pulai is increasingly becoming a species of interest in Indonesia, in part because of its anti-cancer properties (Fadlhi et al., 2012) and other potential economic uses (Effendi et al., 2011). Estimation of genetic diversity within and among pulai populations, and its genetic relationships
using RAPD markers (Hartati et al., 2007), and growth performance of pulai darat (A. angustiloba) between ages 1-5 years in a plantation in South Sumatera (Muslimin and Lukman 2007), have also been reported.

Research on pulai at the Center for Forest Biotechnology and Tree Improvement (CFBTI) in Yogyakarta commenced in 2003. Several populations of pulai were collected from different areas of Indonesia and an *ex situ* conservation area established in Gunung Kidul, Yogyakarta. Information on its tree growth was first published at ages 4 and 11 months (Fiani 2008) but not since then. This study examines the variation in growth of six populations of pulai in this *ex situ* conservation area at age six years. The links between growth performance, climates type and geographical origin are considered and recommendations for a pulai breeding strategy are discussed.

2. MATERIALS AND METHODS

This study was conducted in the special purpose forests area (KHDTK=Kawasan Hutan Dengan Tujuan Khusus) at Petak 93, Playen, Gunung Kidul, Yogyakarta. This *ex situ* conservation area has climate type C according to Schmidt and Ferguson with mean annual rainfall of 1894 mm/year. Soil type is vertisol with a low-to-moderate fertility. The slope ranges from 8-30% and the altitude is around 150 m above sea level (dpl) elevation (P3BPTH, 2004).

Seed from six populations of pulai were collected from West Sumatera and Kupang, Timor Tengah Selatan (TTS), South Sulawesi, West Nusa Tenggara and Bali in eastern Indonesia (Figure 1). A brief description of these seed sources is presented in Table 1 (see Fiani, 2008).

Figure 1: A map of the origin of the six populations of pulai used in this study. White dot points indicate the place of origin. The red circle with white dot point inside indicates the location of the *ex situ* conservation area at Petak 93, Playen, Gunung Kidul, Yogyakarta.

The seeds were sown in July 2006. A total of 0.5 g seeds from each location of pulai was mixed (bulked) until homogeneous. Seeds were sown in tubs containing sterilized sand with Dithane fungicide. The seeds were distributed evenly and then covered with a thin layer of sand; a plastic lid was used to maintain humidity until the seeds had germinated. When the seedlings were approximately 5 cm high, they were transferred into polybags containing a ratio of 3:1 top soil:manure. The six populations of seedlings were planted in the *ex situ* conservation area at Petak 93 in January 2007 in a randomized complete block design (RCBD) with four replications. Each population per replication constituted a square plot with 25 trees (5 × 5) at
the spacing of $2 \times 3$ m between plants. Replanting of seedlings which died was undertaken in January 2008 only.

The assessment of the trial for survival rate, total height, $H$ (m) and diameter at breast height, $D$ (cm) was made on July 2012. Tree volume, $V$ (m$^3$) was calculated using a pulai prediction tree model (Sumadi et al., 2006) where $V = 0.00006918 D^{2.14} H^{0.504}$.

Table 1: The origin of the six populations of pulai used in this study

<table>
<thead>
<tr>
<th>Location</th>
<th>Geographic position</th>
<th>Soil type</th>
<th>Elevation</th>
<th>Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sudiang, Kota</td>
<td>119°25' BT and 5°8' LS</td>
<td>Inceptisol and Ultisol</td>
<td>1-25 m above sea level (dpl) elevation, flat topography with a slope of 0-5%</td>
<td>n.a</td>
</tr>
<tr>
<td>Makasar, South Sulawesi</td>
<td>123°35’ BT and 10°11’ LS</td>
<td>n.a</td>
<td>Hilly terrain with a slope of 45%</td>
<td>Rainfall=1500 mm/year, semi-arid, humidity = 75-76% and temperature =24-34°C.</td>
</tr>
<tr>
<td>Camplong, Kupang</td>
<td>124°3’13”-124°19’56” BT and 9°26’-10°10’ LS</td>
<td>n.a</td>
<td>Elevation = 0-500 m above sea level (dpl) with slope of 0-40%</td>
<td>Rainfall=750 mm/year in average, temperature = 24°C in average.</td>
</tr>
<tr>
<td>Timor Tengah Selatan</td>
<td>100°32’-101°41’ BT and 0°32’-1°41’ LS</td>
<td>Brown forest soil with a sandy loam texture, crumb structure and dense, moderate to good fertility and 25-40 cm thick solum</td>
<td>500-600 m above sea level (dpl), flat topography, choppy, somewhat steep to steep</td>
<td>Climate type = C according to Schmidt and Ferguson, rainfall = 2000-2800 mm/year</td>
</tr>
<tr>
<td>Tanjung Harapan dan Koto, Solok, Sumatera Barat</td>
<td>116°-116°30’ BT and 8°30’ LS</td>
<td>n.a</td>
<td>256 m above sea level (dpl), with flat topography, slope, sloping and slightly undulating with a slope 1-16.5%</td>
<td>Climate type = D according to Schmidt and Ferguson, rainfall = 1500-2000 mm/year, temperature = 22.2°-26.9°C</td>
</tr>
<tr>
<td>Taman Wisata Alam Suranadi, Lombok Barat, NTB</td>
<td>115°35’8.9”-115°54’8.9” BT and 8°-8°41’37.8” LS</td>
<td>Regosol Latosol dan Andosol</td>
<td>n.a</td>
<td>Rainfall vary from 893.4-2702.6 mm/year, temperature 24-30.8°C and humidity 60-90 %</td>
</tr>
</tbody>
</table>

n.a) data is not available.

The percentage survival rate was based on the whole population. For the statistical analysis, mean values based on $H$, $D$ and $V$ of the populations from each block were used. Analysis of variance (ANOVA) and Duncan’s Multiple Range Test were used to examine differences
between the populations in SAS Version 9.00 (SAS Institute Inc., Cary, NC. USA). The correlation coefficients (r) between H, D and V were calculated using EXCEL in Windows 2007.

3. RESULTS AND DISCUSSION

Plant survival measures the ability of pulai populations to adapt to the environmental conditions in the field trial at Gunung Kidul. The survival rate ranged from 64-96%: West Nusa Tenggara had the highest survival rate (96 %), followed by West Sumatera (83 %) and Bali (74 %); the other populations were between 64-66% and the mean rate for all populations 74.5% (Table 2). These survival rates at age six years were generally lower than found previously at age 11 months (77-91%; Fiani 2008), just ahead of replanting. One exception was West Nusa Tenggara that had the lowest survival rate at age 11 months (77%) but the highest survival rate at age six years. While the reasons for this finding remain unclear, it demonstrates that replanting can deliver positive benefits. The most stable population was that from West Sumatera (83 % at age 11 months and 83% at age 6 years). Survival decreased between 17-25% in the other populations.

Table 2. Survival rate of six populations of pulai (*Alstonia* sp.) at age six years in Gunung Kidul

<table>
<thead>
<tr>
<th>Population</th>
<th>Number of trees</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bali</td>
<td>100</td>
<td>74</td>
</tr>
<tr>
<td>Kupang</td>
<td>100</td>
<td>66</td>
</tr>
<tr>
<td>West Nusa Tenggara</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>West Sumatera</td>
<td>100</td>
<td>83</td>
</tr>
<tr>
<td>South Sulawesi</td>
<td>100</td>
<td>64</td>
</tr>
<tr>
<td>TTS</td>
<td>100</td>
<td>64</td>
</tr>
<tr>
<td>Mean</td>
<td>100</td>
<td>74.5</td>
</tr>
</tbody>
</table>

Correlations between all the measured parameters was high. The highest correlation was between H and D (r = 0.976) (Table 3) which demonstrates their very close association. Correlation coefficients between H and V (0.929) and D and V (0.956) also indicated a close association. A significant correlation between H and D though not age and D, D and crown width and D and branching point was also found in a plantation-based study of pulai in Musi Rawas, South Sumatera (Muslimin and Lukman 2007).

Table 3: Correlation coefficient (r) among the measured parameters

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th>D</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (H)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (D)</td>
<td>0.976</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Volume (V)</td>
<td>0.929</td>
<td>0.956</td>
<td>1</td>
</tr>
</tbody>
</table>
There were no significant differences among populations for total height $H$, diameter at breast height, $D$ or tree volume, $V$ (Table 4); there were significant differences between blocks for $V$ but only at a 10% level of significance (Table 4). Similarly, Duncan’s Multiple range test at $P > 5$% of probability only detected differences, this time among populations, for $V$; $V$ of the population from West Sumatera was significantly greater than that for the population from Kupang (Table 5). Nevertheless, examination of Table 5 shows that at age six years, $H$, $D$ and $V$ of the Solok population in West Sumatera are currently superior to those from the other populations. The next best populations are those from West Nusa Tenggara and Timor Tengah Selatan.

Table 4: Analysis of variance for mean total height ($H$), diameter at breast height ($D$) and tree volume ($V$) for six population of pulai ($Alstonia$ sp.) at age six years in an ex situ conservation area in Gunung Kidul

<table>
<thead>
<tr>
<th>Source</th>
<th>Degree of freedom</th>
<th>Sum Square</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, $H$ (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td>3</td>
<td>5.4539</td>
<td>1.8179</td>
<td>1.94</td>
<td>0.1659ns</td>
</tr>
<tr>
<td>Population</td>
<td>5</td>
<td>7.7835</td>
<td>1.5567</td>
<td>1.66</td>
<td>0.2037ns</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>14.0273</td>
<td>0.9352</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter, $D$ (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td>3</td>
<td>2.3855$^4$</td>
<td>0.7952$^4$</td>
<td>2.42</td>
<td>0.1064ns</td>
</tr>
<tr>
<td>Population</td>
<td>5</td>
<td>3.1040$^4$</td>
<td>0.6208$^4$</td>
<td>1.89</td>
<td>0.1558ns</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>4.9256$^4$</td>
<td>0.3284$^4$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume ($m^3$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block</td>
<td>3</td>
<td>3.8493$^{15}$</td>
<td>1.2831$^{15}$</td>
<td>2.52</td>
<td>0.0969*</td>
</tr>
<tr>
<td>Population</td>
<td>5</td>
<td>4.4819$^{15}$</td>
<td>8.9638$^{16}$</td>
<td>1.76</td>
<td>0.1810ns</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>7.6234$^{15}$</td>
<td>5.0822$^{16}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ns* Statistically not significant at 5% level of probability. *) Statistically different at 10% level of probability.

Table 5: Mean total height ($H$), diameter at breast height ($D$) and tree volume ($V$) of six population of pulai ($Alstonia$ sp.) at age six years in Gunung Kidul.

<table>
<thead>
<tr>
<th>Population</th>
<th>Height (m)</th>
<th>DBH (cm)</th>
<th>Volume ($m^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bali</td>
<td>3.46 a</td>
<td>1.91 a</td>
<td>3.53* ab</td>
</tr>
<tr>
<td>Kupang</td>
<td>2.57 a</td>
<td>1.36 a</td>
<td>1.87* b</td>
</tr>
<tr>
<td>West Nusa Tenggara</td>
<td>3.91 a</td>
<td>2.19 a</td>
<td>4.82* ab</td>
</tr>
<tr>
<td>West Sumatera</td>
<td>4.17 a</td>
<td>2.31 a</td>
<td>5.84* a</td>
</tr>
<tr>
<td>South Sulawesi</td>
<td>2.80 a</td>
<td>1.46 a</td>
<td>2.45* ab</td>
</tr>
<tr>
<td>TTS</td>
<td>3.62 a</td>
<td>2.08 a</td>
<td>4.42* ab</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not differ (P < 0.05) by Duncan’ Multiple Range test.

The superiority of pulai from West Sumatera compared to other populations may be related to its ability to adapt to the environmental conditions at the field trial as indicated by its stable survival rate (Table 2). The total height increment of this population was also greatest when the trial was measured at ages 4 and 11 months (Fiani 2008). Other studies have found that taller
provenances/trees are usually being better adapted to a site than smaller provenances/trees (Raebild et al., 2003 in Ginwal and Mandal 2004).

Differences in growth and adaptability are often related to geographic origin and genetics (Ginwal and Mandal 2004). The current study of pulai however found no correlation between growth performance and geographic position. For example, Kupang and Timor Tengah Selatan populations are located at similar latitude and longitude (Table 1 and Figure 1), have a close genetic relationship (Hartati et al., 2007) but had different growth performance. This molecular study of Hartati et al. (2007) also found no relationship between genetic diversity and geographic distribution of eighteen pulai provenances. There was also no correlation between H, D, number of branches, inter-nodal length and survival, and the latitude, longitude and altitude of origin of the provenances of *Acacia nilotica* (Ginwal and Mandal 2004).

Growth performance may have been influenced by climate type as the field trial at Gunung Kidul was of similar climate type (climate type C) to that of the most successful population from West Sumatera, although their mean rainfall was quite different (Table 1). Temperature may be more correlated with growth (Makinen et al. 2000) than precipitation which was quite variable between locations in this trial. However, as Indonesia is located in an equatorial region, little difference in temperature between locations was observed.

The growth performance of pulai at ages 4 and 11 months in the trial at Gunung Kidul suggested that the populations from Timor Tengah Selatan and South Sulawesi were best suited for further development of this species (Fiani 2008). The results from the current measurements at age six years suggest a different approach to a breeding strategy for pulai. A breeding population of two or three sub-lines is recommended. The first sub-line would be based on the best-performing population from Solok in West Sumatera; the second sub-line would combine populations of medium growth performance, those from West Nusa Tenggara, Timor Tengah Selatan, Bali and South Sulawesi; the third sub-line would be the Kupang population, the poorest performer. This approach would be for wood production only. Other strategies may be needed for medicinal purposes. This study examined only two characters, total height, diameter at breast height and volume, however, as pulai has unique growth characteristic, prevost model (Sutisna et al., 1998), so further studies those measure canopy width, branching points, bole height etc are needed to refine the optimum breeding strategy for wood production.

4. CONCLUSIONS

Six populations of pulai planted in an *ex situ* conservation in Gunung Kidul showed differences in growth performance at age six years. Significant differences among populations were found for volume only. The population from Solok in West Sumatera was currently the best for growth performance. There was no correlation between growth performance and the geographical origin of the populations. Climate type may influence growth to a greater extent than topography, rainfall or soil type.

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5. REFERENCES


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