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Population and vegetation structure of ramin (*Gonystylus bancanus*) in secondary forests of Ketapang District, West Kalimantan, Indonesia

ABDURRANI MUIN[1], DWI ASTIANI[1,2,♥]
[1]Forestry Faculty, Universitas Tanjungpura. Jl. Prof. Hadari Nawawi, Pontianak 78124, West Kalimantan, Indonesia. Tel.: +62-561-765342, 583865, 732500, Fax.: +62-561-765342, ♥email: astiani.dwi@gmail.com, abdurrani.muin@gmail.com
[2]Consortium of Tropical Peat Sciences, Kalimantan Universities Consortium. C.q. Universitas Tanjungpura. Pontianak 78124, West Kalimantan, Indonesia

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Abstract. *Muin A, Astiani D. 2018. Population and vegetation structure of ramin (*Gonystylus bancanus*) in secondary forests of Ketapang District, West Kalimantan, Indonesia. Biodiversitas 19: 528-534.* In the tropical peatland, ramin (*Gonystylus bancanus* Miq. Kurz) was one of many prominent species that present in peatland forest. The species distribution is mostly in Southeast Asia peatland. The beautiful wood color, pale yellow sometimes grayish with no differentiated sapwood and heartwood with straight interlocked grain, made it become the most wanted tree species from tropical peatland.The exploitation of Ramin wood since the 1970s caused the decrease of its population in the peatland forest, led to this species being listed as an endangered species. This study aimed to search information on the Ramin population and vegetation structure left in its habitat in secondary peatland forest of Pematang Gadung and Sungai Sirih villages area of Ketapang District. The study employed a survey method, and data collection was carried out using line plots system. Data assessed were natural regeneration condition-seedling, sapling and pole growth levels-, and tree growth levels. A 20 m x 20 m size plots were continually established to form a line with the length of 550-680 m. Results showed that relatively a few Ramin was found in the forests in Sungai Sirih with a mean seedling density of only 9.9 tree ha^{-1}, height ranges of 131 cm to 150 cm, and counted sapling level of 183 trees ha^{-1} with diameter ranges from 0.38 to 6.37 cm. At Pematang Gadung village, more Ramin was found, especially with a bigger diameter. Tree level (diameter >20cm) was recorded at 74.1 tree ha^{-1} with a contradictory far less seedling (2.8 tree ha^{-1}), sapling level (only 1 tree ha^{-1}) and pole level (7.4 tree ha^{-1}) established. Based on the tree population condition and the variation of their growth level, the vegetation structure of Ramin did not describe a normal curve form in the natural forest both in the villages of Pematang Gadung and Sungai Sirih.

Keywords: Growth level, ramin population, ramin structure, secondary forest, tropical peatland

INTRODUCTION

Tropical peatland forest is one of unique ecosystem established in the tropical area of Indonesia. It comprises approximately 10% of land area of the country. It plays many vital roles in the ecosystem, especially in maintaining mega biodiversity including tree species. However, recently it's prominent is under enormous threat from logging, fire, degradation, and land-use and land cover conversion. Lambin et al. (2013) stated that the primary impacts of the landcover changes could be on biodiversity, soil degradation, and the ability of the biological system to fulfill the human need.

Forest degradation and forest conversion could cause a significant impact on tropical peatland forest tree species. One of the prominent tree species in peatland, including the tropical peatland, is ramin (*G bancanus*). Intensive logging disturbance leads to a lack of regeneration of peatland tree species (Astiani 2016) especially ramin trees, the most valuable timber species in peatland forests, which is now listed as vulnerable on the IUCN Red List. Ramin has been exploited for multi-purpose uses, especially for furniture and home decoration (Muin 2009). The wood characters of whitish color and a beautiful, attractive, high-class utility hardwood, soft texture with straight grain, and easy to woodworking made ramin becomes the most attractive wood in the country and abroad. The over-logged of ramin since 1973 to 2008 caused this tree species was listed in CITES as an endangered species and prohibited from logging or trading. Moreover, as the ramin forests themselves were endangered, the fragile ecosystems, where the species growing, are also at risk (Astiani 2016; Astiani and Ripin 2016).

Ramin population is degraded in some peatland forests in West Kalimantan, Indonesia, where ramin used to be found abundant in their original establishment site. Recently, this tree species is only found scattered in some peatland forest spots. In Ketapang, according to the people who are living near peatland forest community, ramin was rarely found in their forest. On the other hand, the communities who live near Pematang Gadung and Sungai Sirih villages in Ketapang District said that they still find some small trees (seedling and sapling growth levels) and some bigger trees in their forest. It is not known how the population of ramin and their vegetation structured is in peatland forest's recent condition. Whether the vegetation structure of ramin is still in normal condition or not to support them to grow sustainably is a key question to be answered. For answering the questions, it is necessary to scientifically study the population and structure of ramin in the sampling areas.

The objective of this study was to search for information of ramin's (*G. bancanus* Miq. Kurz) population and its vegetation structures at peatland forest of Pematang Gadung and Sungai Sirih Villages in Ketapang District of West Kalimantan. The results could be used as a based reference on ramin species development and rehabilitation in these peatland forests.

MATERIALS AND METHODS

Study sites

The study was conducted in the secondary forest area of Pematang Gadung and Sungai Sirih villages of Ketapang District, West Kalimantan Province of Indonesia for three months during March-May 2016. This peatland forest was found to harbor 110 tree species, and was subjected to low-impact logged approximately 5-7 years before, and has peat depth ranged from 2 meters in peatland perimeter and reached ~11 m toward peatland dome. The site map is presented in Figure 1.

Research procedure

To register ramin community in those two sites, the research was carried out using a survey method with continuous line plot procedure on each site. Thirty-three and twenty-seven 20 m x 20 m size plots were used to observe peatland forest natural regeneration consecutively in Pematang Gadung Village covering an area of 1.32 ha and Sungai Sirih Village covering 1.08 ha area including seedling, sapling, pole and tree growth levels. The transects were made perpendicular to peatland landscape edge toward each peatland dome.

Data collection and analysis

The collected data included the amount of young ramin tree per hectare, the height of seedling stage, diameter and height of sapling growth stage, and diameter of pole and tree stages. The research was started with location and observation plot using GPS to determine the starting point and the direction of transects. Within the transects, a 20 m x 20 m size plots were continuously measured along the transect line for their tree species vegetation. The vegetation assessment was done by counting the number and measuring the height of seedlings, diameter of sapling, poles, and trees and identifying the tree species present in each plot of 400 m^2 size. The collected data were analyzed by separating the ramin species found into four growing stages (seedling, sapling, pole, and tree stages) to determine the ramin population found in Gadung and Sirih River, and to describe the structure of ramin vegetation in both locations.

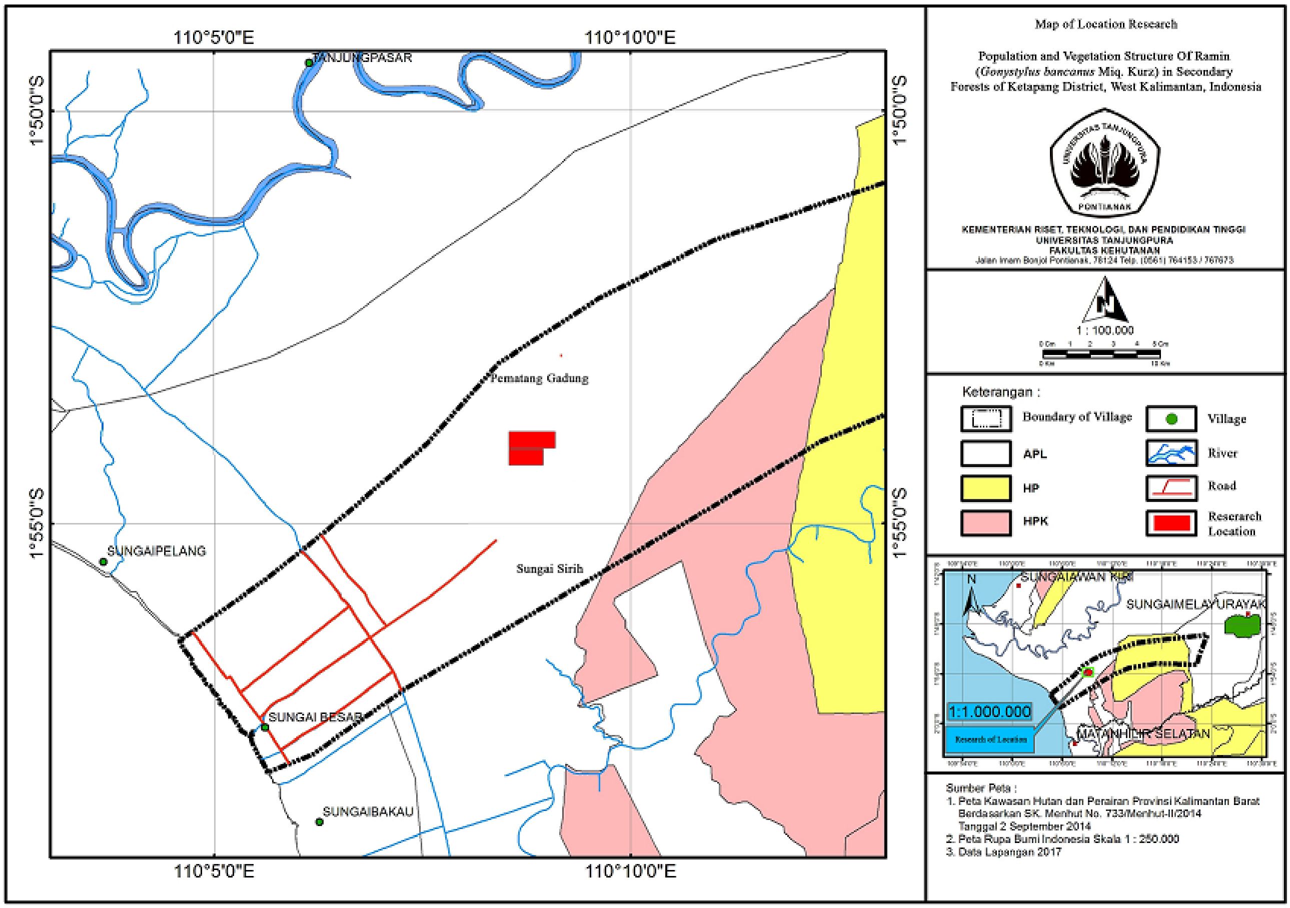

Figure 1. Research site map of Pematang Gadung dan Sungai Sirih in Ketapang District, West Kalimantan, Indonesia

Data analysis was conducted to determine the natural regeneration (seedlings, sapling, poles), tree density within research plots and ramin vegetation structure. Tree density was calculated by summing all recorded trees at each growth stage and then converted into number of tree per ha. Large trees were split into 10 cm ranges to investigate tree structure distribution.

RESULTS AND DISCUSSION

Ramin population

Collected data on the Ramin population found in Pematang Gadung and Sungai Sirih villages, Pantai Selatan Sub-district, Ketapang District are presented in Table 1. The results showed that population of ramin in these two locations varied substantially. The state of ramin in the village of Sungai Sirih, within 1.32 ha of research area, only seedlings and sapling stage were found, while in Pematang Gadung village, with 1.08 ha area, ramin was still found at all levels of growth level (seedlings, sapling, poles, and trees).

The number of ramin population in Pematang Gadung was quite high only at the tree stage/level with diameters >20cm (found ranging from 20-49 cm), while the regeneration rates of seedlings to the pole stages were very low. This condition was very different from that found in the location of Sungai Sirih, where only ramin regeneration in the seedling to sapling stages was found.

Ramin vegetation structure

Research results showed that the structure of ramin vegetation found in the two villages (Pematang Gadung and Sungai Sirih Villages) was not of similar structure. The ramin vegetation in Sungai Sirih Village has a structure that composed only of a lower level tree structure, while that in Pematang Gadung composed of the seedling to the tree levels.

Based on the number of individuals at each growth rate, the ramin vegetation in both villages showed an abnormal structure. In Sungai Sirih Village, ramin vegetation was more dominated by young trees, and there was no pole and tree level found. Meanwhile, in Pematang Gadung Village, the population was dominated by tree level with a diameter between 30-40 cm but the number of regeneration of seedling, sapling and pole stages was very low. Ramin vegetation found in Sungai Sirih has an abnormal tree structure where there were no large trees found asshown in Figure 2. Meanwhile, Figure 3 shows ramin vegetation growth stages from seedling to tree stages.

Although the ramin vegetation found in Sungai Sirih was only at the young growth stages, their diameters fell into classes ranging from 2 to > 6 cm, which indicates that the natural regenerative vegetation of the ramin was at a normal forest structure form as shown in Figure 3. Differences in population and vegetation structure of ramin found in Pematang Gadung and Sungai Sirih villages indicate that there is a difference of activity and intensity as well as the type of felling. Logging of ramin trees in Sungai Sirih about 5-10 years ago was suspected to destroy all ramin trees with a diameter of 20 cm and above. Meanwhile, in Pematang Gadung, intensive harvesting was conducted on non-ramin species.

Table 1. Population of ramin vegetation (*Gonystylus bancanus* Miq. Kurz) in Pematang Gadung and Sirih Villages, Matan Hilir Selatan Sub-District, Ketapang District, West Kalimantan, Indonesia

Tree growth stage	Population (ha^{-1})	
	Sungai Sirih	Pematang Gadung
Seedling (height <1.5 m)	9.9	2.8
Sapling (height >1.5 m-diameter 10 cm	183	0.9
Pole (diameter 10 – 20 cm)	-	7.4
Tree (diameter >20 cm)	-	74.1
Total	192.9	85.2

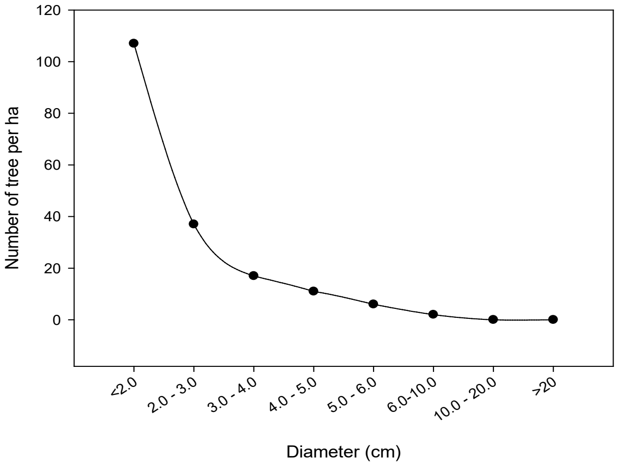

Figure 2. Natural regeneration structure of ramin at sapling growth stage in Sungai Sirih Village, Matan Hilir Selatan Sub-District, Ketapang District, West Kalimantan, Indonesia

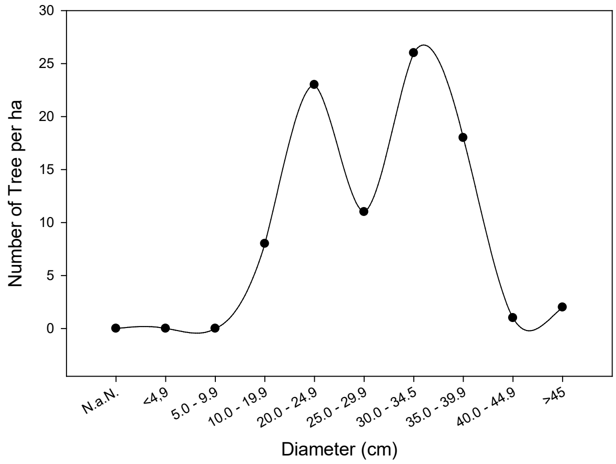

Figure 3. Regeneration structure of pole and tree level ramin in Pematang Gadung Village, Matan Hilir Selatan, Ketapang District, West Kalimantan, Indonesia

Figure 4. Ramin vegetation at seedling, sapling, pole, and tree growth stages. Note: A. Seedling stage (plant height ≤1.5 m), B. Sapling stage (plant height ≥1.5 m-diameter ≤10 cm, C. Pole stage (diameter 10-20 cm), D. Tree stage (diameter ≥20cm)

Previous research conducted by Daryono (2000) in peat swamp forest of Kalimantan and Sumatera islands indicates that ramin was one of the tree species that dominate forest structure in the upper layer. However, after one year of logging, ramin at the trees and pole stages was no longer found. The author (Daryono 2000) stated that the ramin was hunted for logging because of its high economic value so that the ramin stand remains very few in number or nothing left. Furthermore, in their study in the peatland forest of Sanggau District, Muin et al. (2000) found only an average of three stems of ramin at pole stage per hectare. When a logged standing area is not treated (felling of an embark area), then the response will occur, i.e., a shift in the composition of tree species in a stand characterized by a decrease in the proportion of tree species cut in the stand (Suhendang 1995).

The management of ramin forest was carried out by the Indonesian Selective Cutting (TPI) continued with Indonesian Selective Cutting and Planting (TPTI) silviculture system, so that re-construction (including enrichment planting) of logged-over areas should be done. Planting of logged-over areas can only be done using seedlings originating from the nursery. Ramin naturally lives in peat swamp habitat so that peat media should be used for its seedlings (Muin 2009). Appropriate technology is, therefore, required in using the peat soil as the nursery media for ramin seedlings.

Establishment of natural regeneration of ramin vegetation in the secondary forest of Sungai Sirih Village took place because, before harvesting, there were already trees that abort the fruit and form natural regeneration at seedling and sapling level. In this site, wood harvesting was carried out with low impact logging that preferred only a particular type of ramin. It caused the peatland forest were not too destructed, and consequently, the natural regeneration of ramin can grow rapidly to the sapling growth level. The normal structure at this regeneration level indicates that as the adults tree growing older, the number of individuals becomes diminished due to competition among the vegetation present in the habitat. Natural regeneration of ramin in the secondary forest of Sungai Sirih village will form a normal stand if the habitat is free from human or natural disturbance.

Information obtained from the community showed that before the intensive logging was carried out, the existence of regeneration of ramin in the secondary peat forest of Pematang Gadung village was quite abundant in the number of seedling and sapling. However, after intensive logging of various types of mature trees, the natural regeneration of ramin was rarely found in these secondary forest sites. The natural regeneration of ramin vegetation, which is very lacking in the secondary peat swamp forest, is thought to be due to intensive logging of non-ramin trees, thus creating a wide-open trunk (Figure 4). In addition to intensive logging, the canopy opening impacts on the forest floor could be formed as a result of making skid trails of 2-3 meters wide on log harvesting processes.

The decrease of natural regeneration in peat swamp forest in Pematang Gadung Village was not only caused by a drier condition of the sites impacted from the falling mature trees but could also be caused by the wide opening of the canopy on peatland forests (on average more than 24,4 m^2). As a comparison, the opening of the canopy in the secondary peatland forest of Sungai Sirih village was smaller in width (mean ~6.5 m^2). The previous study results by Enrico, Indrawan, and Rusdiana (1999) indicated that harvesting of trees causes the formation of large debris at a logged-over site with varying coverage areas. The cutting of trees that make up the humps of different sizes will change the condition of the microclimate which will affect the decomposition process of organic matter and the life of flora and fauna in the site (Muin 2011). Enrico, Indrawan, and Rusdiana (1999) showed that large-size canopy opening could increase the light intensity from 232.5lx to 1756.5 lx. High light intensity (>25 watts ~ 387.5 lx) is harmful to the natural regeneration of ramin. A Previous study by Muin et al. (2006) revealed that under secondary forests of peat swamps of Sungai Mendawak, Sanggau District, natural regeneration of ramin was found in light intensity between 10.5 watts to 25 watts or 162.8 to 387.5lx.

The sudden open land due to logging activities causes direct sunlight to reach the soil surface resulting in the demise of natural regeneration of ramin. Ramin is a semi-tolerant tree species type where the seedlings cannot survive in open places. This semi-tolerant property of ramin was observed by Muin et al. (2006) in their study took place in the Sungai Mendawak secondary forest, where no ramin natural regeneration was found in open areas. Furthermore, Muin (2007) in nursery trials found that the seeds of ramin sown in an open place grew more slowly and had a smaller leaf size with a slightly yellowish color. In addition to natural regeneration and seedlings growth in the nursery, the semi-tolerant ramin can also be observed from changes in its leaf characters, which are broader and thinner at the seedling stage, and at the larger stages (sapling-tree). The leaf size is smaller and thicker as suggested by Mansfield and Jones 1976) that adaptation to differences in light intensity (irradiance) can be seen in morphology and leaf physiology. Leaves under shade are thinner and broader in leaf surface area than leaves under direct sunlight exposure with more chlorophyll and fewer stomata per unit area.

The results showed that the ramin in the study area developed on peat soil with a peat depth of 2 to 3 m. According to Sabiham and Ismangun (1997), the upper layer of peatland forests is generally dominated by plant residues (litters of stem, branches, leaves) derived from trees (wood-timber). Therefore, the organic material composition at the top of the peat deposits always contains lignin of up to 60% of dry matter, while other materials such as hemicellulose, cellulose, and protein are relatively low. Peat soil fertility in Indonesia is poor (Radjagukguk 1992, 1995; Djuwansah 1999; Subagyo 2000). Based on Radjagukguk (1992) and Muin et al. (2006), soil pH is always in the range of 3-4 and the major mineral elements, mainly N, P, K, Ca Z, Cu and Si, are very low to low levels.

Figure 4. The shape and size of the canopy closure after logging (*left and middle pictures*) and the wood waste left on the ground (*right picture*)

In addition to the application of arbuscular mycorrhizal fungi (FMA), the addition of natural phosphate lime with a dose of 50g polybag^{-1}can accelerate the growth of seedlings in nursery peat media containing high lignin level (Muin 2006, 2007). Sabiham (1996) argued that if peat soil is rich in lignin (due to the origin of wood), it will be difficult to be decomposed and its water contains organic acids that are toxic to plants due to the high phenolic acid content. However, the ability of certain types of fungi to decompose lignin further reduces its toxicity to certain plants (Artiningsih et al. 1999).

Study results of Muin et al. (2000) showed that ramin grown naturally has a symbiotic association with arbuscular mycorrhizal fungi (FMA). Furthermore, Muin (2006) showed that ramin inoculated with FMA and given natural phosphate as much as 50 g polybag^{-1} can improve the quality of seedlings and accelerate the growth of seedlings in the nursery. Muin (2006, 2011) also showed that the FMA inoculated plants grown in logged-over areas grew faster than those without michorizas. Considering the population of ramin vegetation in Pematang Gadung and Sirih Villages, Matan Hilir Selatan Sub-District, Ketapang District, the ramin vegetation in both villages can be categorized as having experienced genetic shrinkage. Such condition indicates that the secondary forest area in both villages can be used as in situ preservation area. Another consideration is to designate these two sites as in situ ramin conservation areas, as it is increasingly difficult to find peatland forests containing regeneration and ramin trees, especially in West Kalimantan.Secondary ramin forest in Pematang Gadung and Sirih Villages is located in Other Use Areas (APL), so to avoid the conversion to non-forest land, the secondary forest area containing ramin vegetation must be determined as a ramin conservation area, which could be done to designate this area to be an Essential Ecosystem Area that should be conserved.

Planting of ramin in the currently existing secondary forest is another kind of natural ramin regeneration, which requires high-quality seeds. Before planting the field, this kind of high-quality seedlings needs to be inoculated with arbuscular mycorrhizal fungi while they are still in the nursery. Further research is required to map and determine the parental trees as seed-producing stands that will be used to grow ramin in in-situ ramin conservation area.

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