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Licensee Practices on Forest Regeneration in Kuala Balah Permanent Reserve Forest, Kelantan, Peninsular Malaysia

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ABSTRACT

Forest regeneration is important to ensure adequate residual stand for the next cutting cycle in poorly stocked logged-over compartment. A regeneration activity has been implemented at abandoned areas to restructure forest contents for quality and healthy composition of timber species. At the skid trails, logs are drag for preparation, stacking and loading out to the log yard. In such areas, trees could not survive naturally as a result of soil compaction. The areas need to be ploughed prior to planting. Forest licensee is responsible for replanting timber trees at log yards, skid trails and ex-logging camp. This study was carried out to determine forest regeneration activities and to identify issues on sustaining timber yield in Kuala Balah Permanent Reserve Forest, Kelantan. The compartment is managed by Kelantan Integrated Timber Complex (KPK). Primary data were collected from 150 respondents from field staff of KPK, sub-contract field workers and nursery labourers who were engaged in the activities. The respondents were given a questionnaire to survey and identify the problems faced during replanting activities. The study found that forest regeneration activities inevitably allowed proportion of vigorous and quality indigenous timber species and artificially increased the volume of specific regeneration into the logged over forest for the next cutting cycle.

Keywords: Forest licensee, sustainable forest management, regeneration, sustaining yield

INTRODUCTION

Sustainable Forest Management (SFM) was developed by the Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 1993, and has been adopted by FAO. It defines SFM as the stewardship and use of forests and forest lands in a way,and rate that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems (MCPFE, 2007). It was recognized by the parties at the Convention on Biological Diversity in 2004 (Decision VII/11 of COP7) to be a concrete means of applying the ecosystem approach to the forest. Both concepts aim at promoting conservation and management practices which are environmentally, socially and economically sustainable, generate and maintain benefits for both present and future generations.

The term “sustainable” was derived from Latin word, “sus-tenere” which means uphold. The concept of sustainability comes from the concept of sustained yield forestry (Pearce et al., 2003; Ferguson, 1996). It balances between forest products and services, and the preservation of forest health and diversity. SFM maintains or enhances the contribution of forests to human well being, both of the present and future generations without compromising their ecosystem integrity that is their resilience, function and biological diversity (Sayer et al., 2005). Obviously, the ecological and economic impacts of SFM depend on a variety of variables - everything from the type of forests involved to the structure of regional economy (Jenkins et al., 1999). SFM means not only management of wood and non-wood resources, but also their processing and creation of appropriate economical structure (Strakhov, 2000). This balance is critical to the survival of forests and to the prosperity of forest dependent communities. However, the level of understanding by loggers is still vague. According to Buang (2001), the progress in establishing SFM was very low and had less impact on the tropical forest.

In Malaysia, the federal government serves as the emblem protector and state serves as the forest managers (Marsh et al., 1992; Mc Morrow et al., 2001). As a member of International Tropical Timber Organization (ITTO), Malaysia has adopted ITTO Guidelines for the Sustainable Forest Management of Natural Tropical Forests and its Criteria for the Measurement of Sustainable Tropical Forest Management (CMSTFM). The silviculture systems applied in tropical forest ecosystems are clear felling or clear cutting, selection felling and shelter wood system (Vandana, 1992). It is a formulated tool, which can be used to conceptualize, evaluate and implement SFM practices. In Malaysia, conventional harvesting of production forests is undertaken on a rotational cycle and a sustained yield management system. Mature trees are tagged for felling at each cycle, thus allowing the logged over area to recover and regenerate before the next harvesting. Under selective logging system, natural forests will return to their former characteristics for better biological functioning. From the point of views of forest licensee, managing a forest in sustainable manner means ensuring for a better benefits for future forest product and services.

Regeneration is a silviculture tool proposed to rehabilitate and to manage harvested forest contents at the maximum level. In particular, it is to enrich the poorly stocked residual stand of loggedover dipterocarp forest by regeneration. Regeneration is when forest licensee selects indigenous commercial species to restore timber trees at post-harvest compartments, i.e. when timber stock and species are inadequate. The activities were devised from the fact that planting was done merely to increase the value per hectare of a forest. Thus, the objectives of this study were to determine forest regeneration practice by licensee and to identify issues on sustaining timber yield in Kuala Balah Permanent Reserve Forest, Peninsular Malaysia.

MATERIALS AND METHODS

Study Area

The study was conducted in Balah Permanent Reserve Forest, in the state of Kelantan, Peninsular Malaysia. The reserve forest is located at 5°16' to 5° 19N and 101° 42' to 101°45'E (see Fig.1). The areas managed under Kelantan Integrated Timber Complex (KPK) are as follows: compartments 42 (70 ha), 43 (258 ha), 46 (215 ha), 114 (198 ha) and 148 (251 ha.) The topography of this area is undulating with slopes ranging from 8 to 55 degrees and elevation above 600 meters. The average rainfall is 2,664 mm per year, while the temperature varies from 27° to 32°C. The driest months are from April to September with an average temperature of 34°C, while the wettest months are from October to February with the average monthly maximum temperature of 30°C. The distribution of rainfall occurs with a major peak in November and a minor peak in March. The area comprised of hill dipterocarp forest. The Dipterocarpaceae family dominates the forest canopy with Shorea curtisii as the dominant species. Other economical valuable commercial species are Shorea parvifolia, Shorea platyclados and Sapotaceae. This ridge forest is characterized by large trees, which are semi-gregarious that forms a dominant stand of large canopy trees along the ridge gigantic soil (FRIM, 2006).

Data Collection

Both primary and secondary data were recorded. Primary data were collected from 150 respondents, namely, the field staff at Kelantan Integrated Timber Complex (KPK) (48), sub-contract field workers (62), and nursery labourers (40), who are engaged in inventory and silviculture activities. The respondents were given a questionnaire each to identify the problems during the replanting activities. In addition, personal interview and site observation were also conducted. Meanwhile, secondary data were compiled from state gazettes, official documents, published report, and other references related to this study. The data were gathered, reviewed and analyzed.

RESULTS AND DISCUSSION

Hill dipterocarp forest of Peninsular Malaysia was characterized by poorly stocked natural regeneration and lack of seedlings in the original residual stand. The

Fig.1: A map of Peninsular Malaysia showing the location of Kuala Balah Permanent Reserve Forest, Kelantan

seedlings are slow in-growth and shade demanding in nature. The objective of Selective Management System (SMS) is to regenerate and to save sufficient number of young potential tree species which vigorously survive from damage during harvesting of the merchantable timber. It is a flexible system which allows determination of the most appropriate cutting regime based on the analysis of pre and post-felling forest inventory data, considering the need of leaving behind sufficient stocking of intermediate sized trees, optimal growth rates and maintaining species composition of the residual forest stand at minimal damage (Hassan-Zaki et al., 2004).

The current forest regeneration practice in this area is conducted based on the prescriptions of post-felling inventory imposed in forest compartment. It is an effort to manage the forest resources in a sustainable manner. The regeneration activities focus on various major aspects related to the technical requirement such as selection of species, prime area in logged over forest, field operation methods, as well as silviculture and map of replanting areas. Activities on regenerating the forest have become more prominent and important in the effort to ensure that relatively poor stocking of logged-over forests is enriched. Several potential commercial indigenous timber tree species that are suitable for regeneration include S. parvifolia, S. curtisii, S. platyclados, Sapotaceae, K. malaccensis, D. costulata, H. odorata, D. aromatica, Pentaspadon spp., S. wallichi, Heriteria spp. and A. borneensis. In this study, the highest number of trees regenerated was in compartment 46. A total of 2,879 trees were planted in the compartment log yards and 4,097 were regenerated in the skid trails. Only 1,841 trees were planted in the log yards in compartment 42 and 903 trees were planted in the main log yard. At the skid trails, there were about 938 trees planted. The difference in the total trees regenerated was due to the size of both the compartments. The size of compartment 46 is 215 ha, while compartment 42 is 70 ha. Five dominant species planted in this compartment are S. parvifolia, Anisoptera, S. leprosula, S. ovalis and S. guiso.

Among the selected species, S.parvifolia is the most desired species planted in the compartments because of the soil and temperature suitability in the areas. In addition, the species has a high growth rate, produce quality wood with high economic values and also market demand. Nonetheless, compartment 148 failed to achieve the target in the main log yard areas, where only 55.14% of the planted trees survived. A total of 72.25% trees in the skid trails survived as a result of the topography characteristics and difficult terrain surrounding the log yard areas. The planted yields could not tolerate desiccation to low moisture contents and remained viable only for a short of period (Chin et al., 1988). The highest achievement in the log yard areas is in compartment 42, with 82.5% survival rate, followed by compartments 43 (80.82%), 114 (76.38%), 46 (76.1%) and 148 (55.14%). In the skid trails, the highest achievement was in compartment 46 with 72.66% survival rate, and this was followed by compartments 148 (72.25%), 114 (67.71%), 42 (67.66%) and 43 (63.21%). However, compartments 42, 43 and 114 had failed to achieve the target of 70.0% survival rates.

This study revealed that the problems faced by the forest licensees are as follows:

1. Inadequate support (43.0%): Inadequate support had made some forest staff to become dependent on the goodwill of concession holders. Yield regulation is very important to ensure sustainability under the SMS. Stocking of yields was not sufficient to sustain the continuity of dipterocarp regenerations in the forest. Seeds have to be quickly sowed in the nursery to restore a higher germination percentage. In addition, proper nursery technique and the preparation of planting stock for seeds are highly required to restore higher germination and critical during the regeneration period. Moreover, since different states make different policies, there is no standard procedure used in executing the forest regeneration techniques. Different treatments will give incomparable results and make it difficult for further study. A comprehensive review of growth and yield (G & Y) data is also essential. The objective of yield regulation is to determine and to ensure that there are sufficient areas for harvesting sustainably during the specific period. The amount is stated as the allowable cut for that period and is usually averaged to a year as the Annual Allowable Cut (AAC). The determination of the AAC is central to SFM as it is to ensure a continuous supply of timber.

2. Climatic or weather conditions (20.0%): The regeneration activities could only be executed during raining seasons and could not to be proceeded when there was no rain for a period of the three consecutive days. The seasons in some areas might be very short. The loggers were much wary of it and thus worked hard to utilize that short period of time to the maximum. For example, the planting months were usually from late August to January in the east-coast states according to the rainy seasons. In particular, the inherent constraints were related to unseasonable climate, which would be overcome to some extent by improving the respective techniques. The areas that were very poor in species composition and wood content are usually in the deeper compartments and remote portions of the forests and need to be enriched.

3. Team work (16.0%): A key factor for SFM is the consideration and involvement of the different stakeholders in various activities. Human factors, such as encouragement of team work, good skill in recognizing appropriate silviculture tools and able to handle work efficiently, can be considered as important elements to ensure the success of regeneration activities.

4. Cost (10.0%): To execute the regenerating activities, the study revealed that the high cost of operation and maintenance was a major problem encountered. Problems related to cost include manpower and labour cost, seedling and yields, fertilizers, silviculture activities, etc.

5. Transportation (7.0%): Transport problem existed when reforestation activities were carried out during bad weather and when logging road is not well maintained by the contractors. Transportation of seedlings to the compartments is one major problem. Distance and shock that had to be endured would render the seedlings as not suitable or ready for planting. Some of the compartments are inaccessible. The only other prerogative to plant in this area is by manual labour to take the seedlings to the planting site which will result in higher seedlings mortality. Healthy seedling is selected through a proper culling process to ensure that those selected can withstand transportation and transplanting shocks.

6. Wildlife disturbances and illegal cultivation (5.0%): Planted seedlings are sometimes mutilated or destroyed completely by wild animals such as wild elephants, wild boars, porcupine etc. Moreover, unscrupulous act of cultivating illegally has been rampant in the states. This is one of the major setbacks faced by the loggers in their effort to execute the regeneration activities. Areas that were once put through regeneration were suddenly cleared and razed to the ground by illegal cultivator. Variable high quality trees were intruded with the planting of fruit trees and other cash crops by the villagers or aborigines, which shifted around searching for fertile areas for upland rice cultivation. Their nomadic culture is an accepted norm. Their next destination of cultivation area could be predictable in some instances, but that this is not necessarily possible in certain cases. Hence, studies that emphasize on effective enforcement of a few simple and basic rules are useful than the proliferation of complex working plans and mathematical yield control methods.

CONCLUSION

Sustainable forest management is a process of managing forest for a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity, as well as undesirable effects on the physical and social environment. Composition, constitution and structure of logged-over forest do not support polycyclic systems and stocking is not sufficient to sustain continuity of dipterocarp management in future. Since the regeneration dynamics and growth of commercial residual trees is not as high as expected, regeneration activities by forest licensees are essential as a means to improve residual stocking that will definitely be able to overcome some of the forest management issues. From the view of forest licensee, managing a forest in sustainable manner means to ensure better benefits for future forest products and services. Based on our study at compartments 42, 43, 46, 114 and 148 in Kuala Balah Permanent Reserve Forest, it could therefore be concluded that forest regeneration activities inevitably allowed proportion of vigorous and quality indigenous timber species and artificially increased the volume of specific regeneration into the logged-over forest for the next cutting cycle. This balance is critical to the survival of forests and to the prosperity of forest-dependent communities. Good forest governance and policy formulations have to be guided through proper long term management of the forest resources by maintaining an optimum equilibrium between resource utilization and the need to protect the environment as a pre-requisite for the sustainable production of forest goods and services.

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Reproductive Patterns of Cynopterus brachyotis (Dog-Faced Fruit Bat) in Bintulu, Sarawak

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ABSTRACT

Reproductive period is a critical phase for most living organism. However, the influence of environmental condition on the reproductive pattern of Chiroptera in Malaysia is not well studied. A study on the reproductive patterns of dog-faced fruit bat, Cynopterus brachyotis,was conducted at Universiti Putra Malaysia, Bintulu Campus, Sarawak. Bats were captured in a planted forest and mixed dipterocarp forest using mist-nets for a period of 14 months from January 2009 to February 2010. The reproductive status was determined based on morphology of the bats. Five (I-Minor testes enlargement, no epididymal distention, IITestes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement) and four (I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active) categories of the reproductive status were categorized for the male and female C. brachyotis, respectively. Bats reproduce at all time of the year and the peak periods are associated with the rainy seasons. The first peak of reproduction (pregnancy and lactation) occurred in January to April 2009 and second peak in June to November 2009. The highest frequency of pregnancy and lactation female coincided with the fruit abundance. The results indicated that C. brachyotis performed a non-seasonal reproductive pattern. The findings are important in understanding the reproductive biology of bats and in protecting this ecologically important and diverse group of mammals.

Keywords: Cynopterus brachyotis, fruit bat, planted forest, reproduction

INTRODUCTION

The environmental factors are known to affect the timing of reproduction in many species of mammals including bats. In bats, the reproductive cycles are affected by photoperiod, rainfall, food abundance, and temperature (Heideman, 2000). Most bat species that have been studied to date display strong seasonality and synchrony in their reproductive cycles such that pregnancies and lactation coincide with food abundance. This increases the chances of the young to survive.

The dog-faced fruit bat, Cynopterus brachyotis (family Pteropodidae), is a common frugivorous species in Southeast Asia, and widely distributed in Malaysia. Throughout its range, this bat species occupies a variety of habitats including primary forest, disturbed forest, mangrove, cultivated areas, orchards, gardens, and urban areas (Funakoshi et al., 1997). Feeding areas and the composition of their food are largely influenced by the seasonal flowering and fruiting of trees (Kofron, 1997). The species appears to be an important seed dispersal agent due to its wide distribution and it is also important in pollination as it feeds on nectar (Funakoshi et al., 1997). Considering its dependence on plants for food and the changing environment (Funakoshi et al., 1997; Phua et al. 1989), the response of C. brachyotis to these factors and the timing of its reproduction are of interest.

Rising development in industries, urbanization, animal husbandry and agriculture has been affecting bats' population. If these man-made disturbances prevail without any perturbation, it will lead to bats' population being threatened with extinction due to habitat loss, decreasing food resources, pollution, deliberate killing and loss of genetic diversity (Meffe et al., 1994). Therefore, a better knowledge on the reproductive biology is important in the management and conservation of this diverse group of mammals. This study was carried out to investigate the synchronization of the reproductive pattern between the male and female C. brachyotis and to correlate it with the climatic and food availability factors.

MATERIALS AND METHODS

Study Site

This study was carried out in planted forest (UPM~Mitsubishi Corporation Forest Rehabilitation Research Project) (113o 03.591' E, 03o 12.691' N) and mixed dipterocarp forest (113o 04.105' E, 03o12.967' N) at Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB) from January 2009 to February 2010.

Bat Trapping

Cynopterus brachyotis were captured using mist-nets that were set along the trails at the vicinity of flowering and fruiting trees and in open areas within the forest. Mist-nets were set up from dusk to dawn and checked at 10 pm and 5 am for 16 days every month for 14 months. All adult bats were recorded and examined.

The bats' body mass (g), length of forearm (mm), sex, and their reproductive status were determined. The reproductive status was assessed based on the morphology. The reproductive status was determined following the characteristics outlined by Happold et al. (1990) and Kofron (1997). Male bats were categorized into five reproductive status (I-Minor testes enlargement, no epididymal distention, II-Testes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement), while four reproductive status for female bats (I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active). Males with testes enlarged and females that were pregnant, lactating and post-lactating were classified as reproductively active individuals (Kofron, 1997). Meanwhile, post-lactating females possessed large, flaccid and dark nipples. Females lacking these characteristics were considered as non-reproductive (Duarte et al., 2010).

Monthly climatic data were obtained from Bintulu Meteorology Station, Sarawak. Opportunistic observations on flowering and fruiting trees (in campus and study area) were also recorded monthly. Statistical tests were done using analysis of variance (ANOVA) to determine the difference in body mass in different months. In addition, Pearson's correlation analysis was done to determine whether there is a correlation between the male and female bats' body mass with the climatic factors (rainfall, humidity and temperature).

RESULTS AND DISCUSSION

A total of 1,328 individual bats comprising of 679 females and 649 males were trapped during the study period. The relationships between body mass in male and female bats with rainfall, temperature and humidity over 14 months from January 2009 to February 2010 are shown in Fig.1. Fig.2 shows the male and female bats' reproductive percentages for the 14 month's period. Bats' body mass was also used as an indirect indicator of their reproductive status. The body mass of the male and female C. brachyotis fluctuated throughout the study period. The highest male bats' body mass was recorded in January 2009 (33.15 ± 6.68 g), whereby it coincided with the highest rainfall (1199.4 mm/month). Food resources are more abundant in the rainy season than in the dry season (Bumrungsri et al., 2007). The highest percentage (24.24%) of status II (testes at or near maximal enlargement, no epididymal distention) was recorded within this wet season (see Fig.2).

In Myotis myotis, fluctuation of body mass can indicate times of food abundance and scarcity (Andreas et al., 2007). During spermatogenesis of Pteropus poliocephalus, the size of the testis increases to indicate the time of reproduction (McGuckin et al., 1991). The testis size of C. brachyotis was enlarged in January 2009, February 2009, July 2009, August 2009, November 2009 and December 2009. This was synchronized with the increase of the body mass of mature males, which might be influenced by the higher food availability (Table 1). According to Tan et al. (1998), C. brachyotis preferred

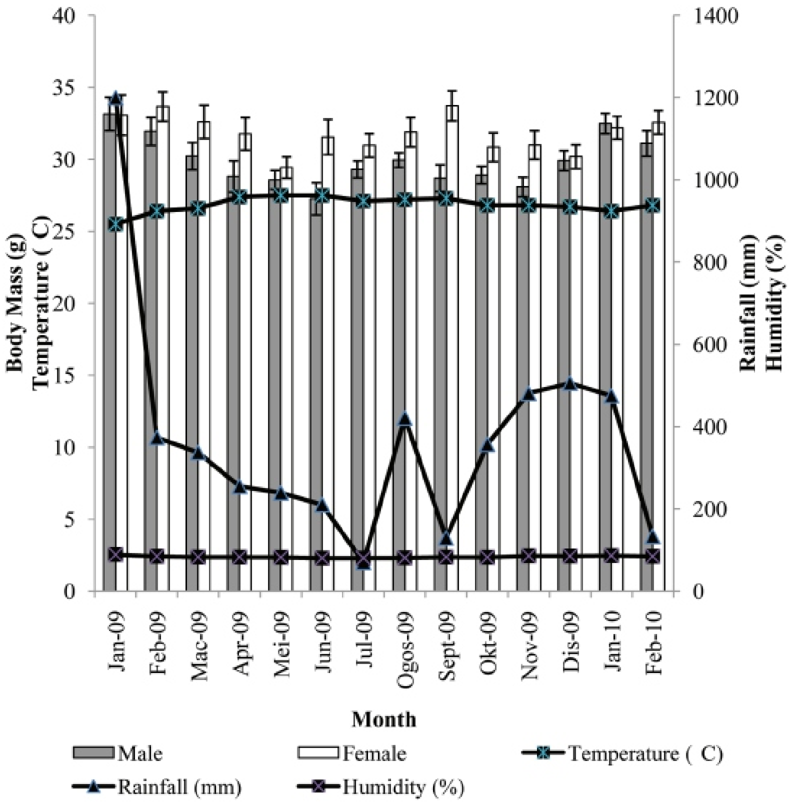

Fig.1: The relationship between the male and female bats' body mass (g) with rainfalls (mm), temperature (o C) and humidity (%) from January 2009 to February 2010 [this study is based on 1328 captures of adult C. brachyotis (male: 51 ± 21.09, female 52 ± 19.74 individuals caught each month)].

to feed on various kinds of non-seasonal fruit.

A study in the testes mass of C. brachyotis showed that the peak mass occurred twice in a year (from June to August and from December to January) (Marina et al., 2002). Meanwhile, a study by Wong et al. (2002) showed that spermatogenesis occurred throughout the year in the population but peaked in the fruiting seasons.

The highest females body mass was recorded in February 2009 (33.65 ± 5.85 g), which occurred a month after the highest rainfall and the highest male body mass.

This could be due to the gestation periods which have caused the increase in body mass. Even though the highest female body mass was recorded in February 2009, the peak of pregnant females (status I) (66.67%) was found to be synchronized with the highest rainfall (see Fig.3). Therefore, rainfall is probably the most important factor in the seasonal reproduction of C. brachyotis. A study by Zortea (2003) indicated that pregnancy peak in Anoura geoffroyi, A. caudifera and Glossophaga soricina occurred in the rainy season.

Food resources are more abundant in the rainy season than in the dry season. Pregnancy, lactation and weaning are the

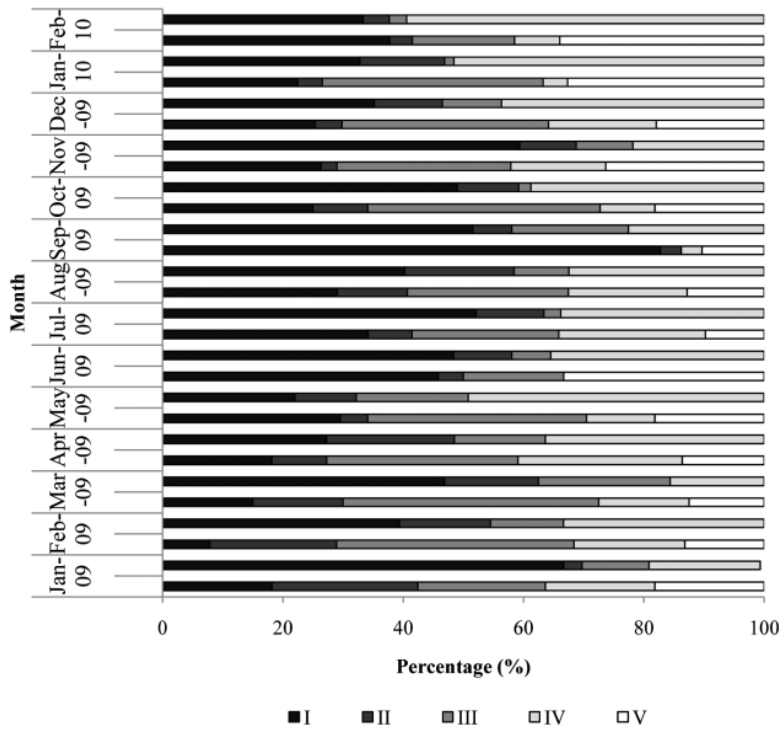

Fig.2: The male (♂) and female (♀) bats' reproductive status (%) for fourteen (14) months period. For male bats: I-Minor testes enlargement, no epididymal distention, II-Testes at or near maximal enlargement, no epididymal distention, III-Testes regressed, cauda epididymal distented, IV-Testes not regressed, cauda epididymal distented and V-No testiscular or epididymal enlargement. For female bats: I-Possibility pregnant, II-Lactating, III-Post-lactating and IV-Not reproductively active.

most energetically reproductive stages; therefore, they should coincide with the period of high food availability (Racey, 1982). Although the highest monthly captures of pregnant females occurred in certain months (e.g., January to March 2009 and June to November 2009), pregnant females were captured every month, suggesting that the breeding pattern is non seasonal. Compared to pregnant females, the lactating females (status II) showed higher captures in April 2009 (21.21%) and August 2009 (18.18%), suggesting that parturition had occurred. Interestingly in Thailand, the birth periods of C. brachyotis was in March to April and August (Bumrungsri et al.2006), which is similar to the present study.

Based on opportunistic observation (Table 1), the fruiting seasons were recorded in January to February 2009 (Mangifera indica, Fragrea fragrans) and June to October 2009 (Nephelium lappaceum, Durio zibethinus, Mangifera indica, Fragrea fragrans, Artocarpus integer). The non-seasonal fruiting trees, such as Ficus sp., show continuous fruit availability throughout the year, as shown by other studies (e.g. Wong et al., 2003; Funakoshi et al., 1997; Lim (1970). Lim (1970) found peaks in pregnancies to occur

TABLE 1

The fruiting and flowering trees in Bintulu (through opportunistic observations)

Month	Flowering and fruiting trees in Bintulu
January 2009	Dipterocarp trees flowering *Mangifera indica* (mango), *Artocarpus integer* (cempedak), *Fragrea fragrans* (tembusu), *Durio zibetinus* (durian)
February 2009	*Mangifera indica* (mango), *Artocarpus integer* (cempedak), *Fragrea fragrans* (tembusu)
March 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
April 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
May 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
June 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), *Fragrae fragrans* (tembusu)
July 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), *Fragrae fragrans* (tembusu)
August 2009	*Mangifera indica* (mango) *Durio zibetinus* (durian), *Nephelium lappaceum* (rambutan), Artocarpus integer (cempedak), Fragrae fragrans (tembusu)
September 2009	*Durio zibetinus* (durian), *Nephelium maingayi* (rambutan), *Artocarpus integer* (cempedak)
October 2009	*Durio zibetinus* (durian), *Nephelium maingayi* (rambutan), *Artocarpus integer* (cempedak)
November 2009	Dipterocarp trees flowering (*Shorea* sp.) *Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
December 2009	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
January 2010	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)
February 2010	*Musa* sp. (pisang), *Piper nigrum* (lada hitam), *Muntingia calabura* (ceri), *Mimusops elengi* (tanjung), *Carica papaya* (betik)

Note: Non-seasonal fruits area available throughout the year

in January, May, and September and these coincided with the fruit abundance. This finding contradicts the results of Kofron (1997) in Brunei, Borneo and Bumrungsri et al. (2007) in Thailand, who found that the reproductive pattern of C. brachyotiswas a continuous bimodal polyoestry with postpartum oestrus. The differences in the C. brachyotis'reproductive pattern are generally associated with different latitudes, which have been found to cause seasonality of rainfall and

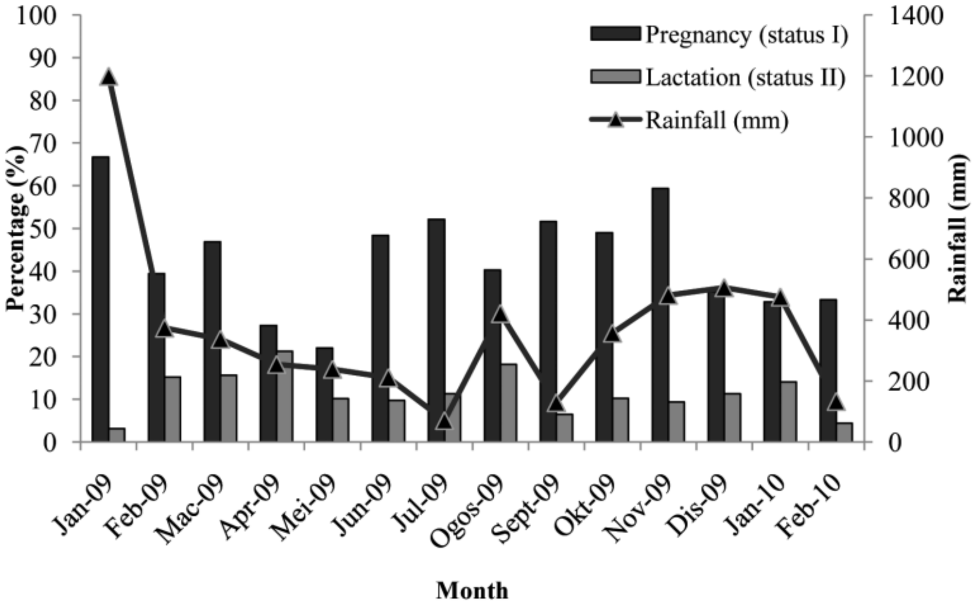

Fig.3: The reproductive status of female Cynopterus brachyotis in relation to rainfall pattern from January 2009 to February 2010.

food availability (Racey et al., 2000). Only the male bats' body mass showed significant correlation ($p<0.05$) with the climatic factors (rainfall, temperature and humidity). Kofron (1997) reported that the increase/decrease of adult males' body mass for C. brachyotis corresponded with the bimodal cycle of ripened mangoes in Brunei. However, the increase/decrease adult female C. brachyotis' body mass did not correspond to the bimodal cycle of ripened mangoes. The results suggest that male bats have to gain more energy for the mating repertoire (vocalizations, body movement, special flight patterns, roost defence, urinary tract markings), which is to pursuit the female partners. On the other hand, the body mass of female bats will increase due to pregnancy.

CONCLUSION

In conclusion, the reproductive pattern of the important seed disperser C. brachyotisis non-seasonal and significant correlation only occurs between male bats' body mass and climatic factor. In-depth information of the reproductive pattern of the species will help promote its protection in the forest.

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Properties of Resin Impregnated Oil Palm Wood (Elaeis Guineensis Jack)

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A B S T R A C T

Oil palm wood (OPW) was treated with medium-molecular weight PF resin (mmw-PF) through a modified impregnation-compression method. The method consists of four steps, namely, drying, impregnation, heating, and hot pressing densification. The objective of the study was to optimize the impregnation variables. The overall density of the OPW increased, whereas the density gradient between the two OPW structural elements (namely, parenchyma tissues and vascular bundles) decreased. The weight percent gain (WPG) significantly increased even with a very short impregnation period (i.e. 1 hour). Young's Modulus of the compression parallel to the grain increased by 15 times (from 170 to 2600 MPa) and the shear strength increased by 7 times (from 1.9 to 13 MPa). The strength of the samples was increased exponentially against density increment. The treatment also made the two OPW structural elements to be strongly bonded that helped in enhancing the durability and machining characteristics of the material.

Keywords: Elais guineensis, oil palm wood, wood modification, properties enhancement, impregnationcompression method

INTRODUCTION

As the second largest palm oil producing country, huge amounts of oil palm biomass (fronds, trunks, and empty fruit bunches) are produced in Malaysia annually. More than 26.2 million tons of fronds, 7.0 million tons of trunks and 23% empty fruit bunches per ton of fresh fruit bunches are resulted annually. These huge residues are becoming a major concern because they cause many problems to the planters and are expensive to be disposed off (Bakar et al., 2005, 2007).

Malaysia and many other countries in the world are now facing problems of wood supply for wood industry. Many efforts have been done to use the oil palm biomass as an alternative material for wood substitution. Oil palm fronds and EFB have successfully been used for fibre-based and particle-based products in Malaysia, and oil palm fibre has been used for paper production in Indonesia. Oil palm stems, however, are still under utilized due to some inherent problems such as instability and density variation of the material (Bakar et al., 2001, 2005).

Oil palm stems are among the three types of oil palm residues that offer the best properties that are comparable to those of wood. The stems can potentially produce oil palm wood (OPW). At the replanting age of 25-30 years, they can reach an average 50 cm in diameter and 10 m in length with 120-130 trees per hectare. This is equivalent to 230-250 m3 of stems per hectare (Bakar et al., 2001). Therefore, huge amounts of OPW can be produced from matured oil palm stems.

As a monocotyledon plant, the best OPW is located at the periphery of the stem, which is in contrast to hardwood logs. Due to this difference, the sawing pattern in producing lumber from oil palm stems needs to be different from that of hardwood logs. The polygon sawing, as shown in Fig.1, is the most suitable sawing pattern. With such sawing pattern, the best tangential outer lumber can be resulted at the highest yield, with a recovery of about 30-35% to the volume of log (Bakar et al., 2006, 2007).

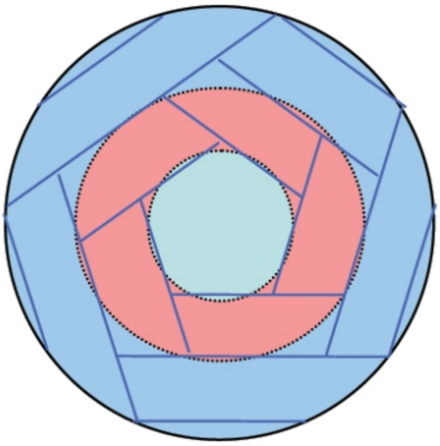

Fig.1: Polygon sawing used to saw the oil palm stem to produce the best tangential outer lumber

It was reported that OPW, even from the best outer lumber, has four main imperfections: very low in strength, very bad in dimensional stability, very low in durability, and very poor in machining characteristic. Hence, finding an effective method to modify the OPW properties has become our main concern (Bakar et al.,2005, 2007).

A number of studies revealed that impregnation treatment and impregnationand-compression treatment using Phenolic resin can improve the strength, dimensional stability and durability of wood, especially when low-molecular weight PF resins are used (Ibach, 2005; Furuno et al., 2004).

Structurally, OPW consists of two main structures, namely; high-density vascular bundles scattered in thin-walled, lowdensity parenchyma ground tissues (Bakar et al., 2008; Shirley, 2002) that amount to 70% of the total volume of the OPW (Istie, 2001). Because of that, OPW has a unique characteristic with high density gradient (between the vascular bundles and the parenchyma tissues) and low overall density. This unique characteristic is considered as the main cause to the mentioned material imperfections.

For OPW, we hypothesized that the impregnation-compression treatment is the most suitable treatment method (Bakar et al., 2007). After the impregnation, the resin will penetrate more into the parenchyma tissues than the vascular bundles and reduce the density gradient between the two material structural elements. Furthermore, the compression densification will improve the structural element compactness and increase the overall density of the material. These effects are expected to not only improve the physico-mechanical properties of the material, but also the machining characteristic.

Therefore, the four-step impregnation compression process was employed in this study (Bakar et al., 2005, 2007). Fig.2 shows the diagram of the process. The objective of the study was to optimize the impregnation variables (i.e. resin concentration and impregnation period) to obtain an effective impregnation-compression treatment method for low-density OPW using mmwPF.

MATERIALS AND METHODS

OPW outer lumbers of 50-mm thick were extracted from matured, 27-year old oil palm stems collected from University Agriculture Park of Universiti Putra Malaysia. The stems were sawn according to the Polygon sawing pattern as described by Bakar et al. (2006). The lumbers were dried to MC of 15 ± 1% and planed on both sides to a predetermined thickness of 40 mm. Only the lumbers with close density range (0.33 to 0.4 g/cm3) were selected for the process. Immediately after being planed, the lumbers were cut short into samples of 40 mm x 100 mm x 100 mm for radial, tangential and longitudinal directions, respectively. The samples were impregnated under compression (120 psi) with mmw-PF under different solution concentrations and impregnating periods. The molecular weight of the resin was about 1000 (according to the supplier specification).

The density of each individual sample was recorded before the treatment. After being impregnated, the samples were redried or heated in an oven set at temperature of 80°C until they reached a target MC of about 50%. This re-drying stage was purposely made to make the resin become partially cured, so that the impregnated samples would not crack during the hot pressing densification, but allow the maximum resin load. Then, the samples were hot pressed at temperature of 150°C for 30 min (until which the resin is assumed

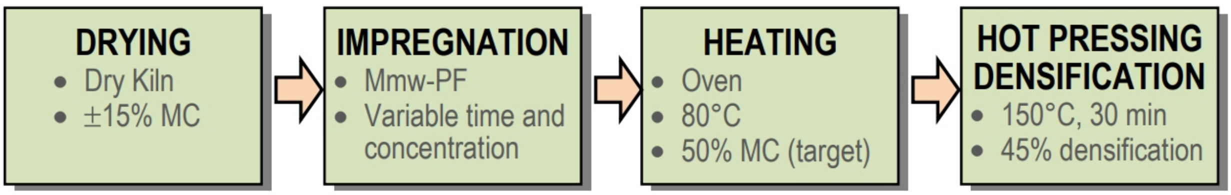

Fig.2: The four-step impregnation-compression treatment process

to be fully cured) until it reached a targeted compression level of 50%. Finally, the samples were conditioned and tested. The compression level was calculated as follows:

$$C = \frac{T_1 - T_2}{T_1} x100\%$$

Where, T_1 is the thickness before the compression and T_2 is the thickness after the compression.

RESULTS AND DISCUSSION

Density

Density is the most important parameter since it affects many other properties of material. The penetration of PF resin into the OPW structure followed by 50% compression increased the overall density of the sample from mean 0.37 g/cm3 to 0.98-1.15 g/cm3, which depended on the solution concentration and impregnation period. This was an increase of almost 3 times in density.The thin-walled parenchyma tissues are more readily to absorb resin (during the impregnation stage) and experience greater level of densification (during hot pressing densification stage) than the vascular bundles. After the treatment, it can be expected that the parenchyma tissues would get greater density gain, and thus, reduce the density gradient between the parenchyma tissues and the vascular bundles. Reduction in this density gradient is expected to affect the other OPW properties to a great extent. Unfortunately, we do not have the apparatus to estimate the density of the two OPW elements for this moment.

PF resin can serve as a bulking and bonding agent in wood (Hill, 2006). These two functions were evident when the mmwPF resin was impregnated in OPW. The bonding function of PF resin gave better compactness to the parenchyma tissues and the vascular bundles. This was expected as one reason why the treated OPW had much better machining characteristic than that of untreated OPW (Fig.3). The study on OPW planing also supports this result (Chong et al., 2011).

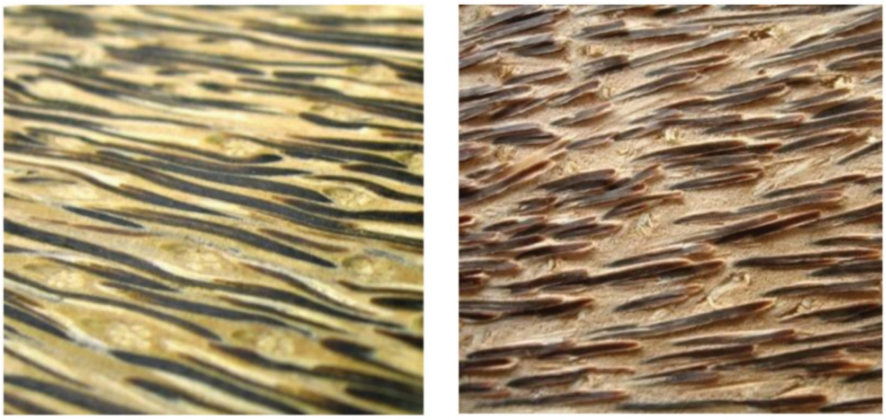

Fig.3: The planing surface of the treated OPW (left) and untreated OPW (right)

Weight Percent Gain (WPG)

The three-fold density increment in the treated OPW mentioned above was caused by two reasons: the 50% densification and the resin uptake. Densification reduced the volume of samples, whereas resin uptake increased the weight of the samples. A high resin uptake, also known as resin load, resin gain, or weight percent gain (WPG), is the main goal in every impregnation treatment of wood (Rowel, 2005). The effect of the treatment condition to WPG is discussed in this section.

The WPGs significantly increased by the increasing of the solution concentration, but they increased less significantly by the increasing of impregnation period (Fig.4). These results suggested that a WPG of 30%, a level which is considered as good enough for better OPW properties, could be obtained with a minimum impregnation period (1 hour) with liquid concentration of 15% to 20%. This is a very short period of impregnation as compared to more than one day needed for the impregnation of softwood with a low-molecular weight PF resin as reported by Furuno et al. (2004).

If WPG is the only parameter to consider, then the solution concentration of 20% with 1 hour impregnation period may be chosen. However, other parameters such as dimensional stability, strength and durability should also be taken into consideration. These are discussed in the following sections.

Anti Swelling Efficiency (ASE)

As mentioned earlier, the dimensional stability is one of the OPW weak points, especially when it is used in solid form (Bakar et al., 2005, 2007). The Anti Swelling Efficiency (ASE) was evaluated to know the effective improvement of the treatment on dimensional stability.

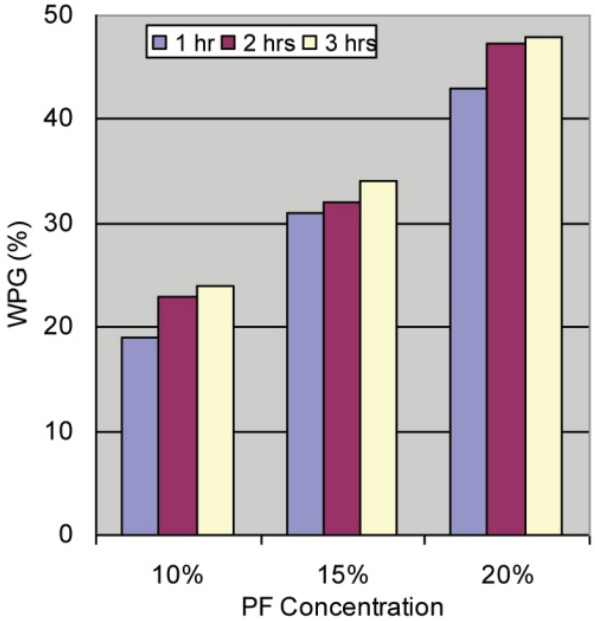

Fig.4: The relationships between PF concentrations and impregnation periods with WPG

An ASE value of 30% was attained by the treated OPW and there was no significant effect of increasing the solution concentration and impregnation period to this parameter (Fig.5). These results suggest that the impregnation with the mmw-PF resin under a concentration of 10 to 15% and an impregnation period of 1 hour were good enough to enhance the dimensional stability of OPW.

It is interesting to note that even though the PF resin used might not penetrate into the cell wall of fibre in the oil palm's vascular bundles (Bakar et al., 2005), it could immediately penetrate into the parenchyma tissues as the bulking agent. This resin penetration helped not only in reducing the density gradient between the parenchyma tissues and vascular bundles, but also blocked the space and access of water soaking test. The blocking effect of the resin seemed to be the main cause to this significant swelling reduction to the treated OPW.

The Strength

The strength is another weak point of OPW when it is used in solid form (Bakar et al., 2005, 2007). Young's Modulus at the compression parallel to the grain and the shear strength were evaluated to know the effectiveness of the treatment. Both Young's Modulus and the shear strength were substantially increased. On average, the Young's Modulus increased from 170 to 2600 MPa (an increment of 15 times) and the shear strength increased from 1.9 to 13 MPa (almost 7 times of increment) after the treatment.It is interesting to note that the Young's Modulus and the shear strength in the treated OPW were increased exponentially over the increment of density. For a better understanding, the specific strength, which is the strength value over the density of

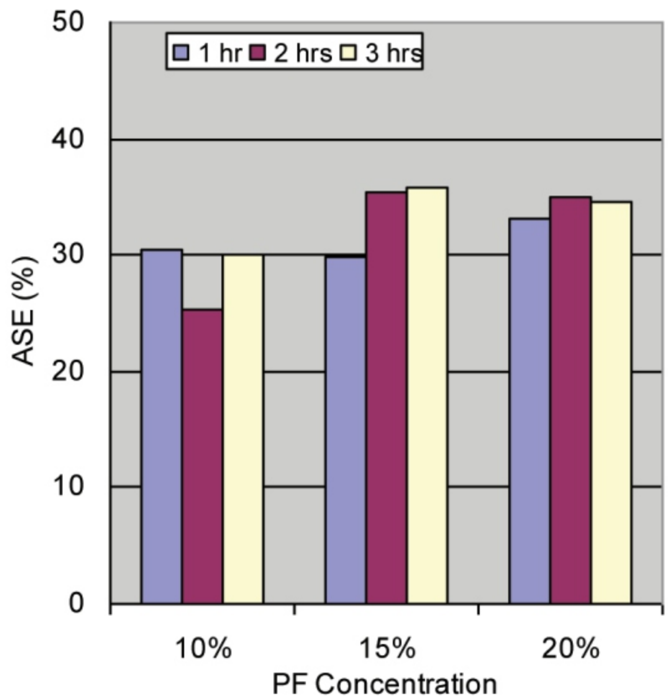

Fig.5: The relationships between PF concentrations and impregnation periods with Anti Swelling Efficiency

material, was evaluated. The specific Young's Modulus was increased by 5 times (from 459 MPa to 2500 Mpa), while the specific shear strength was increased by 2.5 times (from 5.1 MPa to 12.5 MPa). Bulking and binding effects of the resin were expected to be the main reason to these exponential strength improvements.

After being impregnated with PF resin and followed by the hot-pressing densification, the whole density of OPW increased and the two material structural elements became strongly bonded. These two effects were expected to cause a significant improvement in the treated OPW strength. Even though only Young's Modulus and shear strength were tested in this study, we expected that other strength parameters were also improved to a large extent.

Durability

Another weak point of OPW is its durability, which belongs to the perishable durability class (Bakar et al., 2005). The durability of the treated OPW was evaluated through a four-week block test method in accordance with the method described in ASTM D3345-93 (ASTM, 2006). The findings revealed that the mean weight loss of the samples due to the termite attack was substantially reduced from 27.9% (untreated) to only 9.6% (treated). A complete (100%) mortality of termite at the end of the test verified the validity of this test.

As mentioned earlier, OPW consists of two main structural elements, namely, vascular bundles and parenchyma tissues. The parenchyma tissues that amount to 70%of the total volume of the wood (Istie, 2001) contain high amount of starch, and thus, are lower in density and very susceptible to termite and fungal attack. However, the presence of PF resin in the treated OPW, which may be toxic to many fungi and insects, improved the durability of the material. This is in line with the finding from previous studies with both high- and low molecular weight PF resins, that improved the durability class of OPW from perishable to durable (Bakar et al., 2001, 2013).

Machining Characteristics

The other weak point of OPW is its bad machining characteristic (Bakar et al.,2005, 2007). There was no observation made in this study related to this aspect. However, our previous studies revealed that the planing characteristics of OPW were improved from very bad (grade-5) to good (grade-2) (Bakar et al., 2001) or from average (grade-3) to excellent (grade-1) (Chong et al., 2010) after the treatment. Those two studies confirmed that the treatment could significantly improve the machining characteristics of OPW.

Overall, the treatment had substantially improved the properties of OPW, and solved all the four imperfections of the material. In addition, the treatment also gave an attractive red-brownish color to the treated OPW (Fig.3). Hence, with these properties, the material can be used as a high grade alternative material for solid wood.

CONCLUSION

It can be concluded that the four-step impregnation-and-compression process using mmw-PF resin can be used as a practical method to improve the quality of OPW. Based on the properties evaluated, the treated OPW can be proposed as a new high-grade solid wood alternative. On the sectoral aspect, this finding will help reduce the shortage of wood and the dependency of wood supply from forests, as well as solve the problematic oil palm waste disposal in the ground.

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Chemical Characterization of Imperata cylindrica ('Lalang') and Pennisetum purpureum (Napier grass) for Bioethanol Production

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ABSTRACT

Grass is a candidate biomass producer because it is fibrous and it thrives well on poor soils. The chemical properties of two grass species growing naturally and abundantly on idle lands in Malaysia were investigated in this study. The grasses selected were Imperata cylindrical ('Lalang') and Pennisetum purpureum (Napier grass). For the purpose of analysis, Napier grass was further divided into male and female plants, and stem and leaves. Lignin, hemicellulose and cellulose contents were determined using the TAPPI standard methods. 'Lalang' was found not to be an attractive biomass producer because of its high lignin content (22%) ($P<0.05$). On the contrary, Napier grass, particularly the female stem, had low lignin content (13%) ($P<0.05$) and a favourably high level of cellulose (46%) ($P<0.05$). In the female leaf, lignin content was higher (20.7%), while the cellulose content (30.4%) was lower compared to the stem. Although the cellulose content in the male stem (51%) was slightly higher ($P<0.05$) than the female, its lignin was two-fold above that of the female stem, making it a less desirable biomass producer. Hence, it was concluded that female Napier grass has a good potential of becoming a biomass producer in bioethanol production in Malaysia.

Keywords: Bioethanol, biomass, cellulose, chemical properties, grass, lignin

INTRODUCTION

Lignocellulose from grasses is one of the major resources for bioethanol as it has short rotation coppices and it is not suitable for human consumption. The characteristics of being high-yield, low nutrient requirement, together with them being easily available throughout the world, have turned grasses into an attractive feedstock for bioethanol production (Hamelinck et al., 2005; Balat et al., 2008). Bioethanol can be produced from several different biomass feedstocks such as sucrose-containing feedstocks (e.g., sugar cane, sweet sorghum), starchy material (e.g., corn, wheat, rice) and lignocellulosic biomass (e.g., wood, rice husk, and oil palm empty fruit bunch) (Balat et al., 2008). However, the production of bioethanol from starch and sugar has been seriously debated over its sustainability as starch and sugar are important food sources for human (Alvira, 2010). Thus, bioethnaol from lignocellulosic material may be a better feedstock as there will be no competition against food crops. This form of energy has been produced and used in many developed and developing countries (Demirbas et al., 2009). For example, bioethanol was introduced into the transportation fuel supply in 1970s by the Brazilian government (Manuel et al.,2007). However, the potential bioconversion in lignocellulosic biomass is often limited by the associated aromatic constituents within the grass fibre, including lignins and phenolic acids, which act as barriers to fibre degradation (Anderson & Akin, 2008). In order to confirm the potential of lignocellulosic biomass of a plant, the chemical composition of the materials must first be determined as it greatly affects on the efficiency of bioconversion (Lee et al.,2007). Lignocellulosic biomass consists of three polymers: lignin, hemicelluloses and cellulose. Lignin is a complex of phenylpropanoid group, which is a common constituent of plant cell walls (Carpita, 1996). Lignins are highly branched, substituted, mononuclear aromatic polymers in the cell walls of certain biomass, especially woody species, and are often bound to adjacent cellulose to form a complex and recalcitrant structure. The lignin contents in both softwood and hardwood (dry basis) ranged from 20% to 40% and from 10% to 40% in various herbaceous species such as bagasse, corncobs, peanut shells, rice hulls and straws (Yaman, 2004). Hemicellulose and cellulose are bonded together by lignin in the microfibril structure. The basic repeating unit of cellulose consists of two glucose anhydride units called a cellobiose unit while hemicellulose is a mixture of various polymerized monosaccharides (Mohan et al., 2006), which also contains some important C6 sugar (Mohagheghi, 2006). Some of these C6 sugar can be hydrolyzed into glucose for bioethanol conversion use. Alkaline treatment has been used as a pretreatment method to break down the linkage and release the cellulose. In bioethanol process, cellulose is the most important component as it hydrolyzes into glucose and used in microbial fermentation to produce ethanol.

In this study, the chemical contents of two local grass species available in Malaysia were analyzed. Potential grass candidate can be further explored and used for conversion into bioethanol.

MATERIALS AND METHODS

Plant Materials

Two perennial local grass species, namely, Imperata cylindrical (L.) P. Beauv. ('Lalang') and Pennisetum purpureumSchumach (Napier grass) were collected from idle lands at Universiti Putra Malaysia, Serdang campus, and from a housing area in Selangor, respectively. The plants selected were in fresh green condition. Napier grasses were collected during their flowering stage at an average height of 2 m. The whole plant was cut using a cutter, about 0.15 m from the base. 'Lalang' was also collected during the flowering stage at an average height of 1 to 2 m. The napier grass was further divided into stems and leaves. The plants were cut into approximately 3 cm and then oven dried at 50°C until constant weight and later ground into powder form using Wiley's mill. The grass powder was sieved to the size of MESH 40-60 as required by the TAPPI Standard.

Chemical Composition

Plant samples were subjected to different extraction methods according to the TAPPI Standard Method (Anon, 1978), with slight modifications. The adaptation of the TAPPI Standard in this experiment was based on the soft fibre-type of material, which was more similar to the materials found in the pulp and paper industry. Besides, the TAPPI Standard Method is more suitable for the preliminary step to determine the amount of chemical properties in the grass material and it does not require any specific equipment to carry out the experiments, unlike NREL and ASTM. The chemical properties experiment consisted of alcohol-acetone solubility test (TAPPI T6), lignin content test (TAPPI T222), holocellulose content test (Wise et al., 1946) and cellulose content test (TAPPI T203).

Data Analysis

Results were analyzed using SAS program version 9.1.3. (SAS Institute). Procedure Univariate was used in order to determine data normality by conducting Shapiro-Wilk W test and Kolmogorov-Smirnov (K-S) D test. Data were transformed into square root. Procedure General Linear Model (GLM) and Least Square Means (LSM), with probability differences, were used to compare the level of significance between the species, and stems and leaves.

RESULTS AND DISCUSSION

Lignin, holocellulose and cellulose contents of two grass species in Malaysia, 'lalang' and Napier grass were analyzed using the standard methods. Some differences were detected between the species and organ parts. 'Lalang' showed moderate results for the lignin (22.07%), holocellulose (77.69%) and cellulose (51.61%) contents (Figure 1). From the comparison made between 'Lalang' and the male and female Napier grasses, the later had the highest cellulose content ($P<0.05$) (Fig.1). When comparing the stems and leaves of Napier grass, the cellulose content in the male stem was 2.5-folds above that of the leaves (Table 1). Meanwhile, when comparing

TABLE 1A comparison of the chemical properties between Malaysia local grass species and other crops

Species	Extractives	Lignin	Holocellulose	Cellulose
'Lalang'	18.26	22.07[c]	77.69[a]	51.61[a]
Napier grass - male (Stem)	3.20	29.67[a]	76.73[b]	51.44[a]
Napier grass - male (Leaves)	6.51	28.09[b]	72.62[d]	19.60[d]
Napier grass - female(Stem)	2.68	12.93[e]	77.64[a]	46.01[b]
Napier grass - female (Leaves)	14.89	20.74[d]	75.04[c]	30.39[c]
Wheat straw[1]	n/a	17.00	27.60*	40.70
Corn stalks[2]	3.27	19.00	68.18	42.43
Switch grass[3]	17.54	18.13	25.19*	31.98
Softwood[3]	2.88	27.67	21.90*	44.55

*Hemicellulose; n/a: not available

1: Reference from Tomás-Pejó et al. (2009)

2: https://unit.aist.go.jp/btrc/research_result/database/corn-s.htm

3: Reference from Hamelinck et al. (2005) a means with the same letters were not significant

The percentages of lignin, holocellulose and cellulose were calculated by taking into account the material's moisture content.

the female leaves and stems, the lignin and cellulose contents were both higher in the stem ($P<0.05$) (Figures 1a & 1b). Between the female and male Napier grass, the male leaves were found to have less than half of the cellulose in the female leaves ($P<0.05$) (Fig.1a), but the female had less than half of the lignin in the male stem ($P<0.05$) (Fig.1b). Male leaves, on the other hand, had approximately 10% more lignin when compared to the female leaves (Figure 1b). There were not many differences in the cellulose and holocellulose contents of the female stem when compared to the male stem (Fig.1a & Fig.1c). These results indicated that the female Napier grass has a good potential of becoming a biomass producer.

Among the four subsets of Napier grass, the female Napier stem was the best for use in bioconversion into bioethanol as it contained the lowest amount of lignin. Lignin is the biggest barrier in the hydrolysis process because it forms a cross-link linkage with hemicelluloses, which prevents the hydrolysis of cellulose into glucose. In general, stems always contain more fire than leaves. In Rye-grass, the stem (39.5%) has more fibre than the leaf (7.9%) (Smole et al., 2005). In addition, stem-to-leaf ratio increases and cell walls which undergo secondary thicken and lignification during maturation resulting in increased content of structural polysaccharides (mainly cellulose and hemicellulose) and lignin (Lindgren et al., 1980). This explains the higher content of holocellulose and cellulose in the Napier female stem compared to the leaf. In the experiments, 'Lalang' was tested with the whole plant (mixture of stem and leaves); therefore, the Napier grass must be combined to reach a fair comparison.

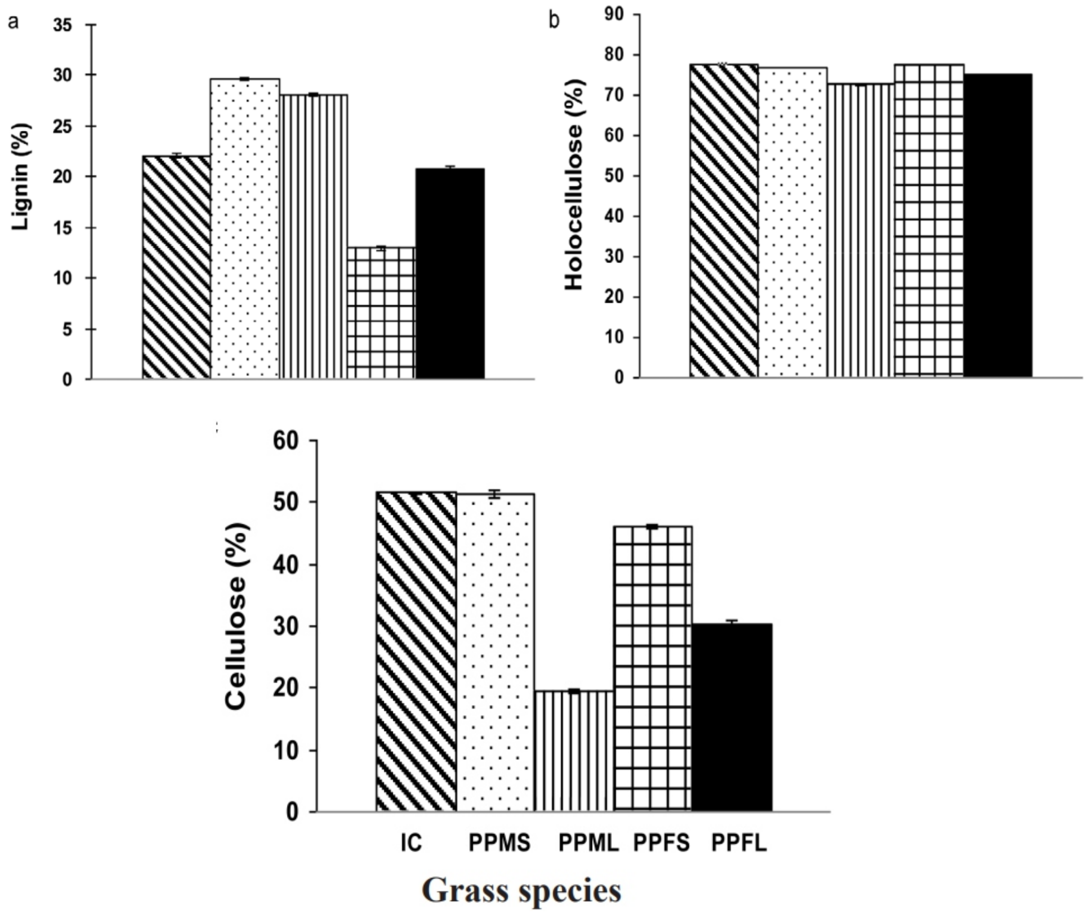

Fig.1: Chemical contents of Imperata cylindrica (IC) and Pennisetum purpureum (PP) found in Malaysia. Data were the means from six replicates and error bars indicate standard deviations. a) lignin, b) holocellulose, and c) cellulose. MS/ML, male stem or leaves; FS/FL female stem or leaves.

Hence, it was proposed to combine the female Napier stem and leaves together so as to recover more holocellulose and cellulose, which in turn will contribute to higher cellulose content.

Hardwood (24%), softwood (27.67%) and other crops such as wheat straw (17.0%), corn stalks (19.0%) and switchgrass (18.13%) (Table 1) showed similar lignin levels to the Napier grass tested in this study. In addition, Napier grass also had higher cellulose content compared to the other crops (30-42%). One interesting comparison between switchgrass and Malaysian Napier grass was that the latter had a similar or a higher content of lignin and cellulose to switchgrass (18.13% of lignin and 31.98% of cellulose). When we compared the cellulose content found in the Napier grass with that of softwood (44.55%), wheat straw (30%) and others (Table 1), the Napier grass appeared to have a great potential as a biomass producer. Napier grass, especially the female grass, had higher cellulose content compared to other crops, while the lignin content was about the same. In more specific, the local Napier grass had higher or about similar lignin and cellulose contents to switchgrass, but lower lignin content than softwood. Lignin can be a problem when it comes to assessing potential biomass as lignin is a major barrier during hydrolysis due to its recalcitrant structure that protects cellulose from being hydrolyzed into simple sugar. The vessel elements of softwood contained mainly guaiacyl units, which restrict fibre swelling and restrict the disruption of lignin structure (Gibbs, 1958; Ramos et al., 1992; Li et al., 2004). Previous research has shown that softwood vessel elements contain a higher ratio of guaiacyl lignins than syringyl lignins (Ramos et al., 1992; Gibbs, 1958). The guaiacyl lignin, which consists largely of coniferyl alcohol, will restrict fibre swelling more than syringyl lignin (Ramos et al., 1992; Henriksson, 2009). Although the HGS-lignin (Hydroxyl phenol, Guaiacyl, Syringyl) in grass contains all three monolignols (p-coumaryl alcohol, conigeryl and sinapyl alcohols), the ratio of p-coumaryl alcohol is a lot higher, i.e. approximately 33% (Henriksson, 2009). Therefore, the restriction of fibre swelling is not as high as compared to softwood and hardwood. These altered structures of the material will help in hydrolyzing cellulose into glucose during hydrolysis. This increases the efficiency of ethanol conversion as the 6-ring sugar (C6) hemicellulose can be easily converted into simple sugar using enzyme hydrolysis or acid hydrolysis method.

The chemical properties determination of lignocellulosic biomass is the first step in bioethanol conversion. The content of chemical properties such as lignin, hemicellulose or holocellulose and cellulose are the main keys to identify the potential of lignocellulosic material in becoming a source of biofuel. Hence, the chemical properties of grasses were determined in this experiment in order to identify the potential of grasses for bioethanol production. We found that the female Napier grass has a potential as a biomass producer.

CONCLUSION

Even though many trees and plants such as Acacia, rubber and bamboo produce high cellulose and hemicelluloses contents, they are also rich in lignin. This study has shown that Malaysia's grasses contain less or similar lignin compared to wood and straw. It could be one candidate source of biomass for bioethanol production due to the desirable chemical properties of having less lignin and high or similar content of cellulose compared to woody and herbaceous plants. Among the samples tested, the female stem of Napier grass is the best candidate to serve as a biomass for bioethanol production. Although there are some difficulties in glucose extraction due to the lignin-hemicellulose recalcitrant structures in the fibre, grass material can be pretreated with chemical pretreatment such as diluted alkaline. The significant low content of lignin allows easy extraction of hemicellulose and cellulose after being pretreated. Therefore, in considering the need for lignocellulosic biomass, Malaysia's local grass seems to be a potential candidate due to its abundant availability and its attractive chemical composition.

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Local Community Participatory Process and Intervention Procedure in Mangroves Ecotourism of Marudu Bay, Sabah

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A B S T R A C T

Mangrove forest extensively colonizes the coastal front of Malaysia, including Sabah state of Northern Borneo. In Marudu Bay in Sabah, it was not harnessed by local communities for ecotourism purposes to complement their incomes mainly from fishing activities. The objective of study was to assess local community's participation in mangrove ecotourism and the intervention procedure needed for success of such a project. The method involved stakeholder analysis using three consultation workshops comprising of key informants and selected villagers as primary stakeholders. Focus Group Discussion (FGD) was followed to elicit responses on ecotourism development within the locals' surroundings and impacts in their daily lives and future undertakings. Results from stakeholder analysis showed that the local communities have the urgency to participate in ecotourism as a new opportunity while supporting mangroves protection. In fact, most of them were found to be willing to provide the services needed to protect the mangrove ecosystem. The intervention needed included support for business activity including ecotourism products and activities development, identification of local leadership/players to spearhead the activities, technology transfer such as technical and facilities assistance, and human capacity building. As for sustainable endeavour, collaborations with big and successful tourism players are crucial to bring their clients to the site as extended visit.

Keywords: Stakeholder, community participation, focus group discussion, intervention procedure, sustainable venture.

INTRODUCTION

Mangrove vegetation is thought to be originated in the Indo-Malayan region. Mangrove forest presents a unique landscape with taxonomically diverse species that serves as a source of lifeline for mangrove communities. The vegetations have subjected to inundation of intertidal waves from high tide to low tide along coastal areas. It plays a crucial role as a habitat for many life forms and ecological processes. The mangroves serve as a giant filtering system of effluents and beaches stabilization and are important for fish breeding and marine life. Mangrove forest comprises of a habitat that is dominated by stands of mangrove trees (Rhizophora spp., Brugueira spp. and Lumnitzera spp.) and other species that adapted well to the local weather and conditions. The wildlife population found in this habitat includes primates mainly the macaque and birds species which comprise of resident and migratory species.

In Malaysia, mangrove forests are widely distributed in several parts along the coastal areas. Mangrove forests provide sources of wood and marine resources besides the amenities for the local communities.

Most village communities are made up of the people who live in the vicinity since ancient times where they traditionally exploited mangroves for commercial products such as timber for construction materials and wood for charcoal production.

In many regions of Asia, local people exploited mangrove forests to sustain their daily lives. The locals encroach into the forests, cut trees, and collect minor forest produce to be sold for economics gains. The mangroves are cleared for aquaculture or physical development. Conservation is neglected, and this leads to further degradation and destruction of those resources. Engagement and participation by the local community in the management of mangrove forests will be able to mitigate the problems. This can be done through ecotourism, which involves low impact activities to the forests. Eco-tourism is defined as 'environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any accompanying cultural features – both past and present) that promotes conservation, has low visitor impact, and provides for beneficially active socio-economic involvement of local populations' (Ceballos-Lascurain, 1996).

Llewellyn (2000) claims that ecotourism also aims to contribute to conservation, sustainable development and poverty alleviation by bringing sustainable benefits to national and local economies.Many people travel to remote places to experience the environment and natural beings found in it. People are brought closer to the environment and with nature based attractions (Wearing & Niel, 1999; Dowling, 2001). Meanwhile, Dowling (2001) identified five important keys that are fundamental to ecotourism. These are nature-based activity, ecologically sustainable, environmentally educative, locally beneficial and able to generate satisfaction among tourists. Hence, ecotourism entails the three core criteria, namely, emphasizing on nature-based attractions, learning opportunities and management practices that adhere to the principles of ecological, socio-cultural and economics sustainability (Blamey, 2001; Fennell, 1999; Weaver, 2001a, b). In related situation, Cato (2009) and Adams (2006) viewed sustainability as a concept that encompasses three main dimensions, namely, social, environmental and economics.

Ecotourism development in many locations connotes economic opportunities, multi-faceted development activities, creative and inter-disciplinary collaboration, interactive engagement with local communities (Abdullah et al., 2000). Among other, it has become an attractive proposition to many protected areas and resource managers. Therefore, the most appropriate ecotourism should be used as a comprehensive and effective management strategy to safeguard the natural environment by means of engaging the local community as a responsible group.

Branton (1999) claimed that setting up ecotourism development in local areas requires careful planning and management through a closed collaboration with the local communities. If it is to contribute to sustainable development, the host community should be given appropriate education in ecology, cultural and its economical importance (Abdullah et al., 2006). The locals have to actively participate and involve in related ecotourism activities when introduced (Wall, 1997; Knowles-Lankford & Lankford, 2000). As ecotourism becomes clear and beneficial to the community development, the locals will realise that they will gain much in increasing their incomes compared to their traditional work. Simultaneously, the locals are able to conserve the natural resources which can be depleting.

Sabah mangrove forests represent a rich biodiversity that can serve as an ecotourism attraction. It has its own uniqueness with its local cultural characteristics for ecotourism development. In Marudu Bay, however, mangroves are still not fully utilized for tourism industry (Ministry of Tourism, Culture & Environment Sabah, 2005). The main problem is that the local community still lack the knowledge and skills required for the ecotourism industry although they realise the benefits that come along with it.The objective of this study was to assess the local community participatory process and the intervention procedure needed in ensuring its success.

MATERIALS AND METHODS

The mangroves in Marudu Bay in Sabah, located in the northern part of Borneo, could be found in dominance covering most of the coastal front (Fig.1). The town of Kota Marudu is located about 130km from Kota Kinabalu (the capital city of Sabah), which is about 2 hours' drive from the city.

Consultation workshops involving three Focus Group Discussions (FGDs) were conducted in the District Office of Kota Marudu made up of the key informants and one in its community hall. The techniques used in this study included identifying issues and main problems identification by the participants. The main focus was to determine the potential for ecotourism based on the mangrove resources in the coastal area of Kota Marudu so as to improve

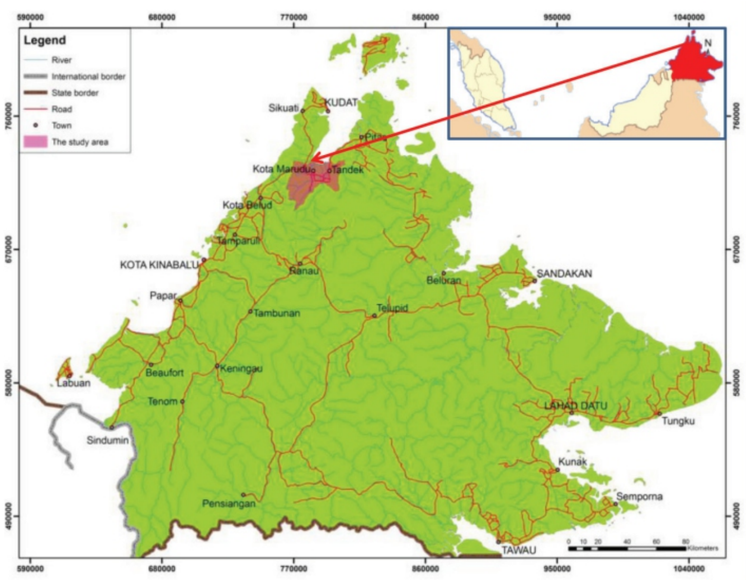


Fig.1: The map of Sabah in Malaysia (inset) and the location of Marudu Bay in Saba

the local livelihood, to increase income and the overall community development. Then, an intervention procedure would be suggested for application to enable the local participations in the ecotourism businesses.

Key informants from 10 villages located in Marudu Bay were chosen for the exercise began from 2009 ended in 2010. One FGD was participated by key informants made up of 22 heads of villages (Ketua Kampung) and one FGD with 40 villagers from the 10 coastal villages, i.e., fishermen, farmers, businessmen, boat operators, etc. The other workshop included the 24 officers, government agencies such as district offices, forest departments, fishery departments, state tourism, NGO representatives and related institutions.

The workshop was administered through brainstorming procedure using facilitation technique by the researchers. Notes were taken and information gathered was analysed so as to design the participatory and intervention procedure for stakeholders (Abdullah & Yip, 2008).

RESULTS AND DISCUSSION

The outcomes from the stakeholder consultation workshop showed that the participants recognised mangrove forest and its surroundings which have rich biodiversities that make up the core components of ecotourism. It possesses the aesthetic, education, and scientific values and a multifaceted socio-cultural ecosystem. The responses also reflected that ecotourism is perceived by the locals as a new opportunity to be developed for everybody's benefits, besides protecting the coastal areas from waves, erosion or pollutions, illegal logging and needs for future generation.

Another crucial issue identified was the locals with low income have the desire for alternative employment. The main problem however is that they have inadequate knowledge and also lack the skills to participate actively in the ecotourism industry. They highly opined that ecotourism development would be able to support their livelihood as they were not satisfied with their present employment. In particular, the locals wanted to be involved as ecotourism operators, meet visitors and work as tourist guides, operate trips to mangroves, islands, wildlife and bird watching, homestay, resort or restaurant operations, or as general workers and boat operators. So far, none of them has been in any form of business ownership or possesses any licence to conduct tourism activities.

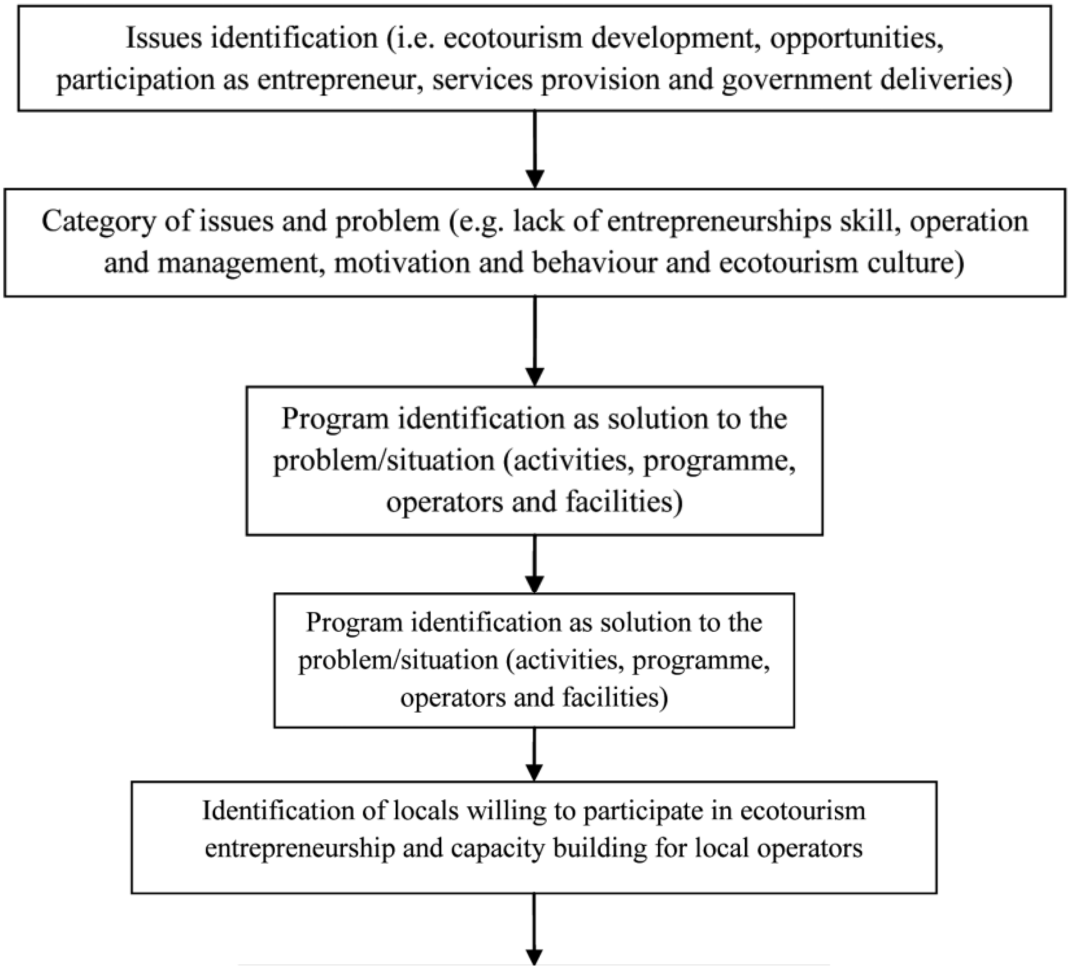
The local people felt that there were no reasons for them not to participate in the ecotourism industry. In fact, they have the interest or motivation, time, and confidence, with family blessing though most of them have no capital, skills or opportunities to start the ecotourism business. Hence, if given the opportunities, capital and entrepreneurship training such hosting or services related businesses, most of the respondents would like start own businesses in the near future. Significantly, the participation from the local community and the benefits generated from ecotourism development would determine the success of the initiatives (Moscardo, 2011). From FGD, the key informants from the government institutions and NGOs provided the information and ideas related to the local ecotourism problems. Marudu is not included in the Sabah Tourism Plan, and therefore, it is not promoted as a tourism destination and being by-passed from the main tourism road, i.e. the Kudat District (e.g. the tip of Borneo as a main attraction).

From the stakeholder analysis, it was found that an intervention procedure is needed. Local leadership or actors have to take up the leading role. During the implementation process, initial support such as field technical assistance is needed to make the activity run uninterrupted and directed as planned (Currie et al., 2009). Activity design, provision of services and supplies, general operation and maintenance of facilities can be developed by appropriate agencies or universities. The locals are very much willing to participate in the ecotourism as individual operators through co-operation or associations.

A summary of the overall participatory process of the local communities in the mangrove ecotourism and intervention procedure when required is shown in a model illustrated in Fig.2.

CONCLUSION

The engagement of the local people through participatory process and intervention procedure will ensure the success of community ecotourism development programme. Identification and prioritisation



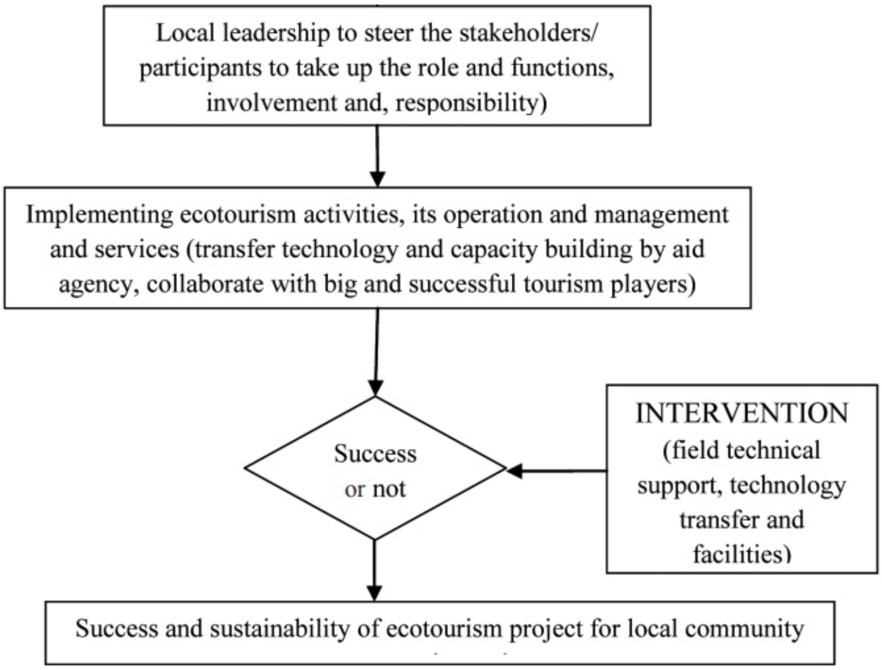


Fig.2: Local community participatory process and intervention procedure in the mangrove ecotourism in Marudu Bay

of the local issues and problems, local community interests are crucial for future development. The local support and willingness to participate in the ecotourism development will help to protect the mangrove ecosystem for sustainable use. These include activities and programme identification and its implementation, determination of local leaderships to spearhead the activities, technical support and facilities required, technology transfer and human capacity building.

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