Ecological and management status of ramin (*Gonystylus* spp.) in Malaysia[1]

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Abstract

Ramin (*Gonystylus* spp.) is one of the important forest tree species that is currently being utilized in Malaysia. In fact, ramin timbers have been exported by mainly Indonesia and Malaysia, which either use for light construction or furniture making purposes. There are 31 species of *Gonystylus*, in which seven species can be found in Peninsular Malaysia, 13 in Sabah and 25 in Sarawak. Out of the 31 species, *G. bancanus* is the most well-known species which represent about 80% of ramin trading in Malaysia. Naturally, this species preferred peat swamp forests, though a study shows it could also survive in non-peat soil areas. Therefore, ecological information and management of the *G. bancanus* have been given special attention by the forest managers and researchers in Malaysia. This paper highlights some important ecological information of *G. bancanus* such as it phenological behaviors and habitat specialization and site-specific management of peat swamp forests in different states of Malaysia. A case study on optimum harvesting for sustainable production of ramin in Pekan Forest Reserve in state of Pahang is presented and discussed in this paper.

Keywords: *Gonystylus bancanus*; peat swamp forest; optimum harvesting; reduced impact logging; Pekan Forest Reserve, Pahang

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Introduction

Gonystylus spp. (ramin) represents among the main important timber species produced by Malaysia. Out of six commercial species of *Gonystylus* spp., *G. bancanus* contributes about 80% of the ramin timbers. This species is confined in peat swamp forests (PSFs). Most of the timber is extracted from the permanents reserve forests (PRF) designated for sustainable timber production. In 2003, there were about 190,000 ha of PSFs in Peninsular Malaysia.

The South East Pahang Peat Swamp Forest (SEPPSF) with an area of about 97,000 ha are regarded as the largest intact PSF in this region (UNDP/GEF 2003). It is the main source of ramin timbers for Peninsular Malaysia, contributing around 90% of the total timber from PSF (Anon 2008). Other major areas of PSF in Peninsular Malaysia are situated in the states of Johore (3,796 ha), Selangor (75,763 ha) and Terengganu (13,757 ha). At the end of 2007, the total area of PSFs for Sabah and Sarawak were estimated at 0.12 million ha and 0.94 million ha, respectively. Main PSF distribution in Malaysia is shown in Figure 1.

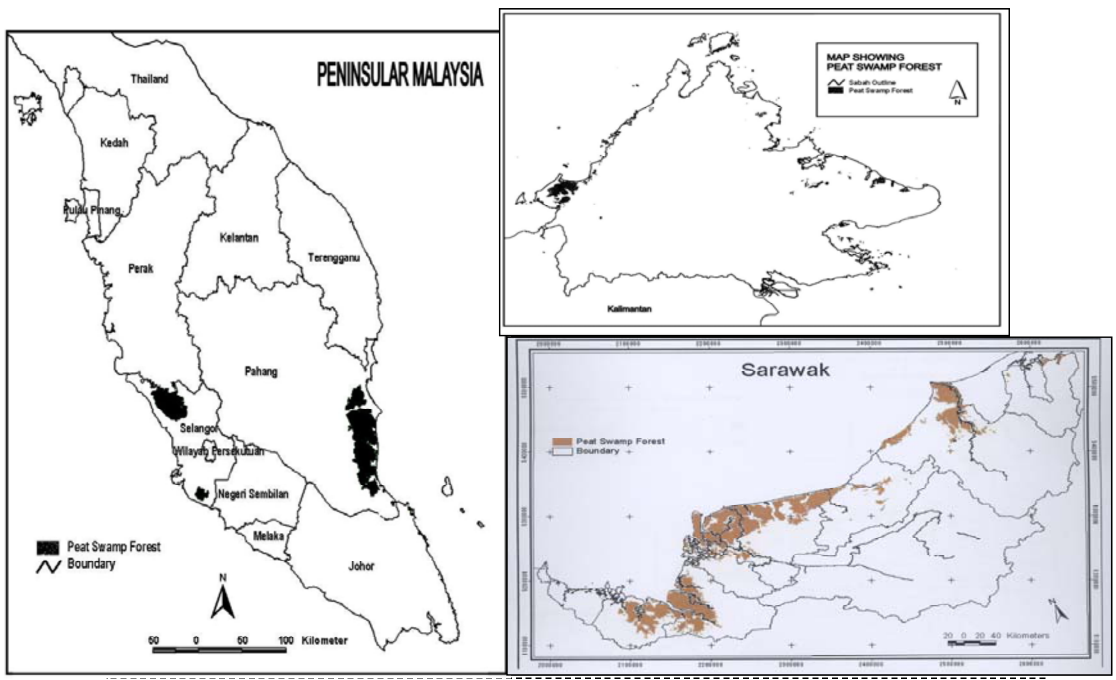


Figure 1. Distribution of main peat swamp forests in Malaysia

Genus of *Gonystylus*

As indicated in Table 1, there are seven species of the genus *Gonystylus* in Peninsular Malaysia (Wyatt-Smith 1999). Among the 31 extant species of *Gonystylus* (Table 2), apart from the seven species in Peninsular Malaysia, 13 can be found in Sabah and 25 in Sarawak (MTIB 2004; Soerianegara & Lemmens 1994).

Table 1. Species of *Gonystylus* in Peninsular Malaysia

No.	Species	Vernacular name (Peninsular Malaysia)	Forest type
1	*Gonystylus acuminatus*	–	dry inland forest
2	*G. affinis*	Ramin dara elok	dry inland forest
3	*G. bancanus*	Ramin melawis	fresh water and peat swamp forests
4	*G. brunnescens*	Ramin daun tebal	dry inland forest
5	*G. confusus*	Ramin pinang muda	dry inland forest
6	*G. macrophyllus*	–	dry inland forest
7	*G. maingayi*	Ramin pipit	dry inland, fresh water and peat swamp forests

Sources: Soerianegara and Lemmens (1994); Wyatt-Smith (1999)

Table 2. Distribution of *Gonystylus* species in South East Asia region

No.	Species	Distribution
1	*Gonystylus acuminatus* Airy Shaw	South and East Borneo, Peninsular Malaysia, Sumatra
2	*G. affinis* Radlk.	Peninsular Malaysia, Southwestern Sarawak, possibly West Kalimantan
3	*G. areolatus* Domke *ex* Airy Shaw	South and East Borneo
4	*G. augescens* Ridl.	Kuching, Singkawang-Benkayang-Mampawah
5	*G. bancanus* (Miq.) Kurz	Southeastern Peninsular Malaysia, Southeastern Sumatra, Bangka, Borneo, Philippines
6	*G. brunnescens* Airy Shaw	Eastern Peninsular Malaysia, Borneo
7	*G. calophylloides* Airy Shaw	Borneo
8	*G. calophyllus* Gilg.	Southwestern Sarawak
9	*G. confusus* Airy Shaw	Peninsular Malaysia, probably Northern Sumatera
10	*G. consanguineus* Airy Shaw	Borneo
11	*G. costalis* Airy Shaw	Borneo
12	*G. decipiens* Airy Shaw	Borneo
13	*G. eximius* Airy Shaw	Borneo
14	*G. forbesii* Gilg.	Sumatera, Siberut, Mentawei, Borneo
15	*G. glaucescens* Airy Shaw	Borneo
16	*G. hackenbergii* Diels.	Sumatra, Kalimantan, Java, Sulawesi, Irian
17	*G. keithii* Airy Shaw	Borneo
18	*G. lucidulus* Airy Shaw	Northeastern Sarawak, Brunei
19	*G. macrophyllus* (Miq.) Airy Shaw	Malesia, Solomon Islands
20	*G. maingayi* Hook. *f.*	Peninsular Malaysia, Sumatera, Northern Borneo
21	*G. micranthus* Airy Shaw	Sarawak, Sabah
22	*G. nervosus* Airy Shaw	Borneo

23	*G. nobilis* Airy Shaw	Sumatra, Borneo, Java, Sulawesi, Irian
24	*G. othmanii* C.S. Tawan	Sarawak
25	*G. pendulus* Airy Shaw	Southwestern Sarawak
26	*G. reticulatus* (Elm.) Merr.	Mindanao
27	*G. spectabilis* Airy Shaw	Borneo
28	*G. stenosepalus* Airy Shaw	Sarawak, Sabah
29	*G. velutinus* Airy Shaw	Sumatra, Bangka, Belitung, probably Borneo
30	*G. warburgianus* Gilg *ex* Domke	Sumatra, Kalimantan, Java, Sulawesi, Irian
31	*G. xylocarpus* Airy Shaw	Western Borneo (Sarawak and Western Kalimantan)

Sources: Cheksum Tawan (1999); UNEP-WCMC (2008); Soerianegara and Lemmens (1994)

***Gonystylus bancanus* (Miq.) Kurz**

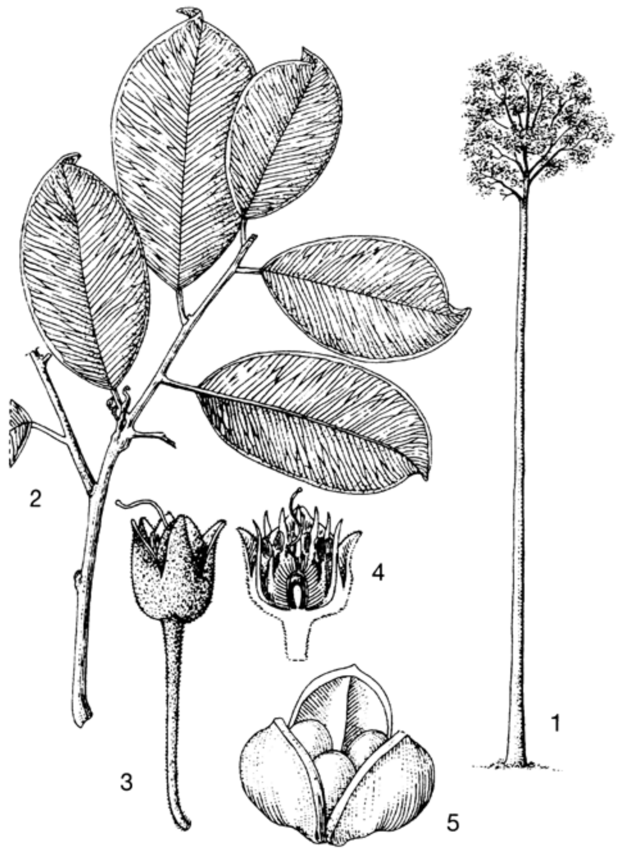
Taxonomy and nomenclature

As stated by Soerianegara and Lemmens (1994), Kurz described *G. bancanus* in 1864. Other synonyms of *G. bancanus* include *G. miquelianus* Teijsm. and Binn., *G. bancanus* Gilg. and *G. hackenbergii* Diels. *Gonystylus bancanus* had been earlier described as *Aquilaria bancana* by Miquel in 1861. However, Kurz transferred it to the genus *Gonystylus* as *G. bancanus* (Miq.) Kurz.

Biology and geographical distribution

As shown in Figure 3, *G. bancanus* is a medium to fairly large tree, which can grow up to 40 m in height with approximately up to 120 cm dbh (Kartiko 2002). The trunk is branchless to 21 m high, the base sometimes fluted with numerous roots as breathing organ (Ng & Shamsudin 2001). Nonetheless, quite a number of *G. bancanus* trees in Pekan Forest Reserve (FR) have branchless trunk more than 30 m (*pers. obs*.). The surface is often cracked and shallowly fissured. The bark is greyish to red-brown, and the inner bark is reddish brown and fibrous (Faridah et al. 2005). The sapwood is white to pale yellowish cream colour (Wyatt-Smith 1999).

The leaves are thick, leathery, elliptical, oblong-oblanceolate or obovate and are frequently folded lengthwise. The veins are numerous, almost parallel but not reaching the margin. The inflorescences are up to 9 cm long, densely tomentose. The flowers are arranged in 2 to 5 clusters, 1 to 1.8 cm long. The fruits are in capsules, woody, rounded and open at maturity. There are 1 to 3 seeds per fruit (Figure 4). The seed is ovoid, dark in colour and about 28 x 22 x 6 mm in size and there are about 250 - 300 seeds per kg (Kartiko 2002). Seeds of *G. bancanus* have a reasonably high percentage of germination with 95% as reported by Ismail and Shamsudin (2003) and about 63% as reported by Shamsudin (1996).



Gonystylus bancanus (Miq.) Kurz – 1, tree habit; 2, sterile twig; 3, flower; 4, sectioned flower; 5, dehisced fruit.

Figure 3. Habit of *G. bancanus* (Soerianegara & Lemmens 1994)

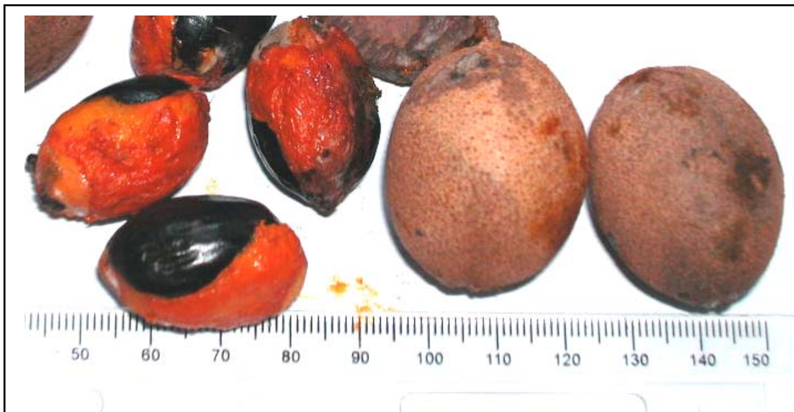


Figure 4. Fruits and seeds of *G. bancanus*

The distribution of *G. bancanus* covers Peninsular Malaysia, Borneo, Sumatra, Papua New Guinea and the Philippines (Soerianegara & Lemmens 1994; Whitmore 1984). According to Kartiko (2002), *G. bancanus* is mainly distributed in Indonesia (western and central Kalimantan, southeastern Sumatra and Bangka), Malaysia (southeastern Peninsular Malaysia, Sabah and Sarawak) and Brunei Darussalam (Figure 5). The species is a lowland species rarely found above 100 m in altitude. It grows in freshwater coastal PSFs, occasionally forming pure stands (CITES 2004).

Figure 5. Main distribution range of *G. bancanus* (Kartiko 2002)

Ecology and general growth development

According to Shamsudin (1997), *G. bancanus* is abundant in primary PSF in Pahang and a dominant species in size class of $\geq$70 cm dbh. This is supported by studies of Blackett and Wollesen (2005) and Ismail et al. (2005). They reported that *G. bancanus* is the second most abundant species after *Calophyllum ferrugenium* var. *ferrugenium* in Pekan FR of trees in size class of $\geq$30 cm dbh.

Naturally, young individuals of this species tend to clump together within a small area underneath the mother trees (Shamsudin & Ng 1995). It is believe that limited distance of seed dispersal due to fairly large and heavy fruits might one of the reasons that give *G. bancanus* the tendency to be clumped. Regeneration is mostly within a parameter of 10 m radius from the mother trees. The number of seedlings decreases with the increase in distance and no single seedling has been recorded at the distance of 20 m away from the mother tree (Nurul Huda 2003; Shamsudin 1996). In a ground survey of a *G. bancanus* dominant area, it was commonly observed that several big-sized trees ($\geq$ 30 cm dbh) were naturally distributed within 10 m^2 (Ismail et al. 2005).

There are also some studies conducted to investigate germination rate and vegetative propagation of *G. bancanus*. Shamsudin (1996) and Ismail and Shamsudin (2003) reported on germination rate of *G. bancanus* at about 63 and 95%, respectively. The *G. bancanus* was also found possible to propagate via vegetative propagation with rooting ability of about 70% (Mohamad Lokmal et al. 1993) and 51% (Ismail & Shamsudin 2003). A related study by Guanih (2005) using misting system recorded 75 – 93% survival and rooting percentages ranging of 65 – 80%. On top of that, the species also has the potential to produce plantlets through tissue culture (Shamsudin & Aziah 1992). The characteristics are adequate to justify the availability of quality planting materials of *G. bancanus* for planting programme naturally or even as forest plantation (Ismail et al. 2007).

In addition, Ismail et al. (2007) reported that the species showed a promising growth performance in planting trials conducted at non-peat swamp areas. Eleven-year-old planted *G. bancanus* showed survival of about 52% while diameter and total height increments were of 0.95 cm $year^{-1}$ and 69 cm yr^{-1}, respectively. Ismail et al. (2006) have recommended *G. bancanus* for forest rehabilitation programme in PSF. This was based on a rehabilitation study conducted in highly degraded PSF in Raja Musa FR, where *G. bancanus* showed more than 70% survival. The species was also used in planting trials in secondary PSF at Sungai Karang FR, Selangor and logged-over PSF in Pekan FR, Pahang which yielded promising results of survival of more than 70%, especially those trees planted using the line-planting technique.

Phenological behaviours

A study to investigate the phenological behaviour of *G. bancanus* was conducted at Pekan FR, Pahang (Ismail 2008). Based on this study, it was determine that the flowering type for *G. bancanus* is supra-annual. It was observed that, one important factor that possibly triggers *G. bancanus* to flower was period of flooding. It was found the species flowered in a situation of prolonged flooding due to the longer monsoon season. The smallest *G. bancanus* tree observed to flower was 29.0 cm in diameter located in a logged-over site. Nonetheless, most of trees that flowered were those having larger diameter of more than 40.0 cm, either in logged-over or virgin forests.

A total of 71–86 days was recorded for full development from bud to matured fruit formation (Table 3). The budding development phase was fairly long, more than a month; however, it took a relatively short period for the flower to become fruit of only about two weeks. Flowers of *G. bancanus* were pollinated by thrips (*Heterothripts* sp.) and stingless bees (*Trigona canifrons* and *T. laeviceps*). Identified predators of the *G. bancanus* flowers and fruits are aphids (*Aphis* sp.), Prevost's squirrel (*Callosciurus prevostii*) and Plantain squirrel (*C. notatus*). *Gonystylus bancanus* seed is dispersed naturally by normal gravity. In addition, Malayan flying fox (*Pteropus vampyrus*) was identified as the animal species that disperses the fruits. Some fruit bats (Table 4), namely *Cynopterus sphinx*, *Megaerops ecaudatus* and *Penthetor lucasi* were also identified as the potential seed dispersal agents of the *G. bancanus*.

Table 3. Development of phenological phases in 2007 fruiting season

Phenology development	Duration (range in days)	Remarks
Bud to flower	36 – 46	about 30% of buds became flowers
Flower to fruit	10 – 15	about 26% of the flowers became fruits
Fruit maturity and fall	25 – 38	about 21% of the fruits were matured
Total (range in days)	71 – 86	

Table 4. List of bats present in the forest habitat of SEPPSF

No.	Species	Vernacular name
1	*Balionycteris maculata*	Spotted-winged fruit bat
2	*Chironax melanocephalus*	Black-capped fruit bat
3	*Cynopterus sphinx**	Short-nosed fruit bat
4	*Megaerops ecaudatus**	Tailless fruit bat
5	*Penthetor lucasi**	Dusky fruit bat
6	*Rhinolophus sedulus*	Lesser woolly horseshoe bat
7	*Rhinolophus trifoliatus*	Trefoil horseshoe bat

Note: * identified as possible seed dispersal agent for *G. bancanus*
Source: Lim (2007)

Forest Management in Malaysia

The Selective Management System (SMS) practices in Malaysia stipulates that harvest quotas be set annually (annual coupe). This quota is determined for every five years by the National Forestry Council which is chaired by the Deputy Prime Minister. The allocation of the annual felling coupe for the PRF is based on forest inventory data, net area of production forest, and prescribed silvicultural management practices. For the period 2006–2010, the annual coupes for the PRFs in Peninsular Malaysia, Sabah and Sarawak, including all dryland and wetland forest types, have been set at 36,940 ha, 60,000 ha and 170,000 ha, respectively, which are about 1.2%, 2.0% and 2.8% of their respective production forest areas. Annual coupe is calculated based on harvestable production area; the annual volume to be removed should be less than or equal to mean annual increment.

In Malaysia, the cutting cycle under SMS (otherwise known as forest harvesting rotation) is approximately 30 years with an expected net economic outturn of 40-50 m^3 ha^{-1}. Growth rates, residual stand, and the required final stand determine the length of the cutting cycle. Higher growth rates and residual stand content are expected to lead to shorter cutting cycles and higher annual coupes (Thang 2002). SMS adopts a selective cutting approach based on minimum diameter limit. Different minimum cutting limits are applied for different timber groups. For example, *Neobalanocarpus heimii* (Dipterocarpaceae, chengal) has a cutting limit of 60 cm dbh, other dipterocarps species are harvestable at 50 cm dbh, while non-dipterocarps are cut at 45 cm dbh. The State Forestry Department is required to prepare and implement a 10-year Forest Management Plan, a 5-year Forest Development Plan and an Annual Forest Operation Plan. These plans provide guidelines for the management, conservation and sustainable development of forest resources in the State and Districts.

Forest Management in Peat swamp forests

In terms of forest management of PSF, the present cutting limits in Pekan FR, Pahang are set as 50 cm dbh for *G. bancanus* and 55 cm dbh for other species. The cutting cycle is set to be at 55 years. Meanwhile, cutting limits for trees of PSF in Selangor is set at minimum of 45 cm and 50 cm for non-dipterocarps and dipterocarps species, respectively (Saharudin 2004). Therefore, actual cutting limits are varies depends on their timber stocking that obtains from Pre-felling inventory conducted before the felling activity. The cutting cycle in PSF of Selangor is also set at 55 years. In Terengganu and Johore, no commercial activities are reported due to small size of PSF areas in these particular states.

PSFs in Sarawak are being managed with a modified uniform silvicultural system (Chai 1997). Mixed swamp forests (MSF) in Sarawak have been logged since the 1950s due to their accessibility and occurrence of highly valuable *G. bancanus* stands, especially those situated at the outer rims of the dome-like structured PSFs. From 1970 to 1984, approximately 8,000 ha of MSF have been logged annually (Chai 1997). The PSF in Sarawak adopts a cutting cycle of 40 to 60 years depending on factors such as species composition and expected growth rate with a minimum cutting diameter fixed at 40 cm (Sia 2005). As a note, all PSFs in Sabah are classified as totally protected forests (Class I) that only use for conservation purpose.

Case study on Optimum Harvesting of Peat Swamp Forest in Pekan Forest Reserve, Pahang

FRIM was allocated about RM790,000 (~USD226,000) by the Malaysian government under Levy Fund to determine the harvesting regime for PSF in Peninsular Malaysia. In these studies, Compartment 77 in Pekan FR has been selected as the study site. The area is productive rich forest of ramin-bintangor subtype located in northeast of the forest reserve (Blackett & Wollesen 2005). The ramin-bintangor subtype is representing about 20% (~10,000 ha) of the whole Pekan FR. An area of 100 ha in the Compartment 77 was allocated for this study to present actual harvesting practices in the ground. The study areas were divided into four blocks of 25 ha, which used in testing of different cutting options developed by the project. Four set of cutting regimes had been developed based on primary and secondary data collected (Table 5). The cutting regimes were prepared by taking into account species dominance in the area, volume of timber to be taken out and number of residual trees and main species to be retained as future crops.

Table 5. Selected cutting limits for species group in each harvesting block

Block	Cutting limit	Description
1	50 – 45 – 40	low cutting limit
2	55 – 45 – 40	medium cutting limit
3	60 – 50 – 45	medium cutting limit
4	65 – 55 – 50	high cutting limit

Note: Cutting limits for species group: 1 – 2 – 3
1 = *G. bancanus* and dipterocarps only,
2 = *Callophyllum* species only,
3 = other species.

The cutting regimes were tested by using Rimbaka Timber Harvester or simply called as Rimbaka. The machine is one type of RIL method developed by local logging company. After the harvesting, post-harvest assessments was conducted to determine the impacts of each cutting options on the forest stands. In the assessments, actual damage of the residual trees of the different cutting regimes due to the harvesting operations were assessed. Besides the physical and ecological assessments, an financial assessment was also conducted. Both assessments were used to determine final harvesting regime that most suitable for the PSF.

Results of damage assessments that conducted after the completion of harvesting operation are shown in Table 6. There were total of 547, 547, 643 and 659 trees of ≥ 15 cm dbh recorded in Blocks 1, 2, 3 and 4, respectively. Total number of trees survived were 467 (85.4%), 468 (85.6%), 538 (83.7%) and 582 (88.3%) for Blocks 1, 2, 3 and 4, respectively. Meanwhile, total number of trees died for all species for Blocks 1, 2, 3 and 4 were 80 (14.6%), 79 (14.4%), 105 (16.3%), respectively. The total number of survived trees of all species that had no damage at all (intact) were 318 (58.1%), 315 (57.6%), 427 (66.4%) and 460 (69.8%) in the respective blocks. The number of survived trees that suffered some damage were 149 (27.2%), 153 (28.0%), 111 (17.3%) and 122 (18.5%) for Blocks 1, 2, 3 and 4, respectively.

Table 6. Results of damage assessment (dbh ≥ 15 cm)

Parameter	Block 1	Block 2	Block 3	Block 4
Total number of trees surveyed	547	547	643	659
Total number of trees died	80	79	105	77
Percentage (%)	14.6	14.4	16.3	11.7
Total number of trees survived	467	468	538	582
Percentage (%)	85.4	85.6	83.7	88.3
Total number of trees survived with damages	149	153	111	122
Percentage (%)	27.2	28.0	17.3	18.5
Total number of heavy damage trees	66	63	72	70
Percentage (%)	12.1	11.5	11.2	10.6

Total number of medium damage trees	58	43	21	22
Percentage (%)	10.6	7.9	3.3	3.3
Total number of light damage trees	25	47	18	30
Percentage (%)	4.6	8.6	2.8	4.6
Total number of undamaged trees (intact)	318	315	427	460
Percentage (%)	58.1	57.6	66.4	69.8

It was found felling activity as the main reason of died trees in the harvesting operation as shown in Table 7. Therefore, it can be concluded that the RIL is giving minimum impact to the residuals stands and the timber extraction is only contributing to small portion of trees that died during the harvesting operation.

Table 7. Causes of trees died of harvesting operation on different blocks (dbh $\geq$ 15 cm)

Cause	Block 1	Block 2	Block 3	Block 4
Felling	71 (88.8%)	65 (82.3%)	70 (66.7%)	68 (88.3%)
Extraction	9 (11.2%)	14 (17.7%)	35 (33.3%)	9 (11.7%)
Total	80 (100.0%)	79 (100.0%)	105 (100.0%)	77 (100.0%)

In term of timber production, total timber production in study areas of 100 ha was 8,821.58 m^3. Apparently as assumed due to lower cutting regime, Block 1 had highest timber production, followed by Block 2, 3 and 4 with 110.53, 106.14, 85.02 and 51.18 m^3, respectively. In this study, volume mean annual increment (MAI) and optimum cutting cycle are projected. It shows that the volume MAI for each block is not far different, in the range of 1.75 – 1.84 $m^3 ha^{-1} yr^{-1}$. While, optimum cutting cycle is varies in the range of 30 – 45 years depending on the blocks.

Meanwhile, total cost of timber harvesting in the study site (100 ha) was 22,476.70 ha^{-1}. Cost of felling consuming bigger portion with 51.42% followed by administration and pre-felling costs with 46.44 and 2.66%, respectively. Based on the financial analysis that used 10% interest rate for 35 years cutting cycle, showed that the values of net present value (NPV) were positive for timber harvesting in Block 1 (RM230,095.90 ha^{-1}), Block 2 (RM212,351.64 ha^{-1}) and Block 3 (RM132,157.20 ha^{-1}), but negative value in Block 4 (-RM5,622.43 ha^{-1}). It shows that timber harvesting is viable in Block 1, 2 and 3, while not viable in Block 4. As outputs of this study, it is suggested to use cutting limits of Block 3 [60 (ramin & dipterocarps) – 50 (bintangor) – 45 (others)] as minimum cutting limit in the ramin-bintangor subtype at Pekan FR with cutting cycle of 35 - 40 years.

Based on this study, RIL has shown considerably low damage impacts on the residual stands. It was found that log extraction, the main part of the RIL method, only contributed a small portion to the overall damage or tree mortality as compared with the felling operation. It is clear that the implementation of the RIL method in PSF helps to minimize damage to the residual stands. It showed that the RIL method had successfully produced relatively low damage and mortality of the residual stands and therefore should be continued and encourages to be used in harvesting of the PSF areas.

Conclusion and Recommendation

In general ecological information for *G. bancanus* are relatively adequate. In general, efforts have been made to ensure management of this species is taking into account its ecological characteristic. The management of habitat of this species particularly on the timber harvesting has got special attention in order to sustain their production. Nonetheless, continuous research and improve management practices of the species and its habitat are still necessary to ensure its sustainability for economic and ecological purposes. Furthermore the species are listed in Appendix II of CITES, in which their timber trading is based on annual quota. However, it was observed that the ecological information of other *Gonystylus* spp. are still lacking and therefore critical to be given more attention. If necessary, special management practices of the species might needed to increase their production that possibly could further reduce pressure on dependency to the timbers of *G. bancanus*.

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