EFFICIENCY OF BLANKET AND SELECTIVE CLIMBER CUTTING AT DERAMAKOT FOREST RESERVE, SABAH

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Abstract

Efficiency of Blanket and Selective Blanket Climber Cutting in Deramakot Forest Reserve, Sabah

The efficiency of blanket (BCC) and selective climber cutting (SCC) in terms of time and cost, regenerative capacity of cut climbers and growth rate of Potential Crop Trees (PCTs; 5≤30 cm DBH) in Deramakot Forest Reserve, Sabah (DFR) was investigated in this thesis. This study was conducted in Compartment 60 and 61 of DFR which were representative of the logged forests in Sabah. The experimental design for this study was a uni-factorial randomized complete block design (RCBD) that comprised of three 50x50m plots in a Block with ten replicates. The climber density (> 1 cm DBH) in the study site was enumerated only in the Control. Climbers (> 1 cm DBH) were not enumerated in the BCC and SCC but assumed to be similar with the Control. In BCC and SCC, only climbers on tress greater than 30 cm DBH were enumerated. The density of climbers greater than 1 cm DBH in DFR was 404±235 stems ha^{-1}, belonging to 46 species in 34 genera and 24 families. Climber densities on trees greater than 30 cm DBH in BCC, SCC and Control were 159±142 (SD), 164±100 and 117±64 stems ha^{-1}, respectively. All climbers were removed in BCC while only climbers on trees greater than 30cm DBH were removed in SCC. Climbers were intact in the Control. The time taken to cut climbers in BCC [45.73±17.92 (SD) minutes ha^{-1}] was 52% longer than SCC [29.99±7.72 minutes ha^{-1}; Paired t-test; N= 10; t=2.293, p=0.048]. The number of coppiced climber stumps, after cutting between BCC (8%) and SCC (5%) after 6 months was not significant (Pearson Chi-Square; N=10; χ^2=1.667, df=1, p=0.197). The Relative Growth Rate (RGR) of PCTs in BCC was 0.057±0.02 (SD) cm $month^{-1}$, SCC was 0.043±0.017 cm $month^{-1}$ and Control was 0.036±0.012 cm $month^{-1}$. A significant difference in RGR was found between BCC and Control (Tukey's HSD; p=0.032) but none between BCC and SCC (Tukey's HSD; p=0.183). Given that SCC was as efficient as BCC treatment, SCC should be adopted in DFR, Sabah.

Keywords: climber cutting, blanket and selective climber cutting, Deramakot Forest Reserve, Sabah

Abstrak

Keefisienan pemotongan akar secara menyeluruh (BCC) dan terpilih (SCC) berasaskan masa dan kos, pertumbuhan semula pepanjat dan kadar pertumbuhan relative (RGR) pokok-pokok tebangan akhir (PCT; 5≤30 cm DBH) di Hutan Simpan Deramakot, Sabah (DFR) telah dikaji dalam tesis ini. Kompartment 60 dan 61 dipilih sebagai tapak kajian di DFR sebab kedua-dua kawasan ini adalah setanding dengan hutan-hutan yang pernah dibalak di Sabah. Rekabentuk kajian ini adalah berbentuk pemblokan menyeluruh secara rawak (RCBD). Kepadatan pepanjat (> 1 cm DBH) di kawasan kajian ini hanya dicerap di Kawalan sahaja. Pepanjat (> 1 cm DBH) tidak dicerap di BCC dan SCC kerana kedua-dua kawasan ini dianggap memperoleh kepadatan pepanjat yang serupa dengan Kawalan. Di BCC dan SCC, hanya pepanjat pada pokok lebih daripada 30 cm DBH dicerap. Dalam rekabentuk ini terdapat tiga plot 50x50m dalam satu Blok dengan 10 replikasi. Di Kawalan, terdapat 404±235 pepanjat ha^{-1} yang lebih daripada 1cm DBH dan terdiri daripada 46 spesis, 34 genera dan 24 famili. Kepadatan pepanjat pada pokok lebih daripada 30cm DBH di BCC, SCC dan Kawalan ialah 159±142 (SD), 164±100 and 117±64 pepanjat ha^{-1}. Di BCC, semua pepanjat adalah dipotong manakala hanya pepanjat yang berada pada pokok lebih daripada 30cm dipotong di SCC. Di Kawalan, tiada pepanjat yang dipotong. Masa yang diperlukan untuk BCC ialah [$\bar{x}$=45.73±17.92 (SD) minit ha^{-1}] iaitu 52% lebih panjang berbanding SCC [$\bar{x}$=29.99±7.72 minit ha^{-1}; T-test; t=2.293, p=0.048]. Pertumbuhan semula pangkal pepanjat akibat BCC (8%) didapati tiada perbezaan nyata dengan SCC (5%) selepas enam bulan (Pearson Chi-Square; N=10; χ^2=1.667, df=1, p=0.197). Kadar pertumbuhan relatif (RGR) bagi PCTs di BCC, SCC dan Kawalan ialah 0.057±0.02 (SD) cm sebulan 0.043±0.017 cm sebulan dan 0.036±0.012 cm sebulan. Terdapat perbezaan yang nyata di antara BCC dan Kawalan (Tukey's HSD; p=0.032) tetapi bukan di antara BCC dan SCC (Tukey's HSD; p=0.183). Didapati bahawa keefisienan SCC adalah setanding dengan BCC Jesteru itu, SCC adalah disyorkan di DFR, Sabah.

Kata kunci: *pemotongan akar, pemotongan akar secara menyeluruh dan terpilih, Hutan Simpan Deramakot, Sabah*

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LIST OF ABBREVIATION

ANOVA	-	Analysis of variance
AMSL	-	Above mean sea level
ASL	-	Above sea level
BCC	-	Blanket Climber Cutting
CL	-	Conventional Logging
DBH	-	Diameter at breast height
DFR	-	Deramakot Forest Reserve
FSC	-	Forestry Stewardship Council
ITTO	-	International Tropical Timber Organization
MC&I	-	Malaysian Criteria and Indicators
MGS	-	Minimum Girth System
MMUS	-	Modified Malayan Uniform System
PCT	-	Potential crop tree
POM	-	Point of measurement
RCBD	-	Randomised complete block design
RIFS	-	Regeneration and Improvement Felling System
RIL	-	Reduced Impact Logging
RM	-	Ringgit Malaysia
SCC	-	Selective Climber Cutting
SD	-	Standard deviation
SFD	-	Sabah Forestry Department
SPSS	-	Statistical Package for the Social Sciences
SUS	-	Stratified Uniform System
US	-	United States

LIST OF SYMBOLS

\$	-	Dollar
%	-	Percentage
$<$	-	Less than
$>$	-	Greater than
$\leq$	-	Smaller than or equal to
$\geq$	-	Greater than or equal to
$^{\circ}$	-	Degree
′	-	Minute
″	-	Second
$\bar{x}$	-	Mean
$\pm$	-	More-or-less
C	-	Celsius
cm	-	Centimetre
d^{-1}	-	Evapotranspiration
e.g.	-	For example
ha	-	Hectare
ha^{-1}	-	Per hectare
$hour^{-1}$	-	Per hour
i.e.	-	That is to say or in other words
Km	-	Kilometre
m	-	Metre
mm	-	Millimetre
m^2	-	Square metre
m^3	-	Cubic metre
Mg	-	Megagram
t	-	Tonne

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Climbers are plants that grow and climb over other plants to reach forest canopy for sunlight. The herbaceous climbers are known as vines, and the woody climbers are known as lianas (Bongers *et al.*, 2002; Parren *et al.*, 2003; Putz, 2006; Gerwing *et al.*, 2006 and Schnitzer *et al.*, 2007). Climbers are very conspicuous and contribute substantially to the diversity and structure in tropical forests (Putz, 1984; Putz and Chai, 1987; DeWalt *et al.* 2000; Nabe-Nielsen, 2001; Schnitzer and Bongers, 2002 and Phillips *et al.*, 2005). Climbers typically represent about 10–25% of the woody species density and diversity in tropical forests (Muthuramkumar and Parthasarathy, 2001; Nabe-Nielsen, 2001 and Schnitzer and Bongers, 2002). They can also achieve as high as 44% of the species in some forests (Pérez-Salicrup *et al.*, 2001a).

Climbers play an important role in the forest ecosystem. They represent about 5% to 14% of the total aboveground forest biomass and of significance as a carbon sink (Putz, 1983 and Gerwing & Farias, 2000). Climbers' biomass tend to increase after disturbances due to natural treefall, logging and hurricane occurrence (Babweteera *et al.*, 2000; Schnitzer *et al.*, 2000; Schnitzer and Carson, 2001; Schnitzer and Bongers, 2002; Caballé and Martin, 2001; Schnitzer *et al.*, 2004). In one study conducted in Central Amazon, climber's biomass had increased by 7% within 100 m of the fragmented forest edge following disturbance (Laurance *et al.*, 2001).

Climbers also provide essential food and pathways for arboreal vertebrates and invertebrates (Putz, 1984; Putz, 1985; Putz and Chai, 1987; DeWalt *et al.* 2000; Nabe-Nielsen, 2001; Schnitzer and Bongers, 2002 and Phillips *et al.*, 2005). Emmons and Gentry (1983) reported that primates favoured climbers for food and used them more frequently when the forests had high abundance of climbers.

Moreover, high diversity and density of climbers can provide many inter-crown bridges for the arboreal vertebrates e.g. prehensile tailed vertebrates in the Neotropics and gliding vertebrates in Asia to travel across canopy (Emmons and Gentry, 1983 and Dudley and DeVries, 1990). Climbers may also serve as host for canopy insects such as ants, homopterans, and beetles (Odegaard, 2000). Blüthgen and Fiedler (2002) found that climbers from the Leguminosae family play a role in housing homopterans and weaver ants in the Australia's rain forest canopy.

Foresters, however, see climbers as nuisance because they complicate harvesting operation by intertwining and interconnecting crowns and stems of surrounding trees. The presence of climbers on harvest trees also increased felling damages and canopy gaps during timber extraction (Putz, 1984; Appanah and Putz, 1984; Putz, 1985; Putz and Chai 1987 and Pérez-Salicrup *et al.*, 2001b). Climbers which attach to fallen trees could resprout and reinvade the forest rapidly due to their unique stem cells and climbing mechanisms (Putz, 1983, 1984 and 2006; Ewers *et al.*, 1990; Ewers and Fisher, 1991; Pinard and Putz, 1994; DeWalt *et al.*, 2000 and Schnitzer and Bongers, 2002). In addition, climbers impede tree growth, regeneration and productivity by competing with trees for water, nutrients and, light (Stevens, 1987; Pérez-Salicrup and Barker, 2000; Pérez-Salicrup, 2001; Gerwing, 2001 and Grauel and Putz, 2004).

As a measure to reduce incidental damages during timber harvesting, it is common practice to remove all climbers 6 to 12 months prior felling opreation (Fox, 1968; Liew, 1973a; Chai and Urdarbe, 1977; Appanah and Putz, 1984; Cedergen, 1996; Vidal *et al.*, 1997; Pérez-Salicrup and Barker, 2000; Pérez-Salicrup, 2001; Pérez-Salicrup *et al.*, 2001b; Gerwing and Uhl, 2002; Gerwing and Vidal, 2002; Alvira *et al.*, 2004; Schnitzer *et al.*, 2004; Grauel and Putz, 2004). In doing so, felling damages were reduced by approximately 30-50% (Fox, 1968; Appanah and Putz, 1984; Liew, 1973a and Cedergren, 1996). In performing pre-harvest climber cutting, climber densities could be reduced by 9-55% and remain low for years (Appanah and Putz, 1984; Vidal *et al.*, 1997; Parren and Bongers, 2001; Gerwing and Vidal, 2002; Gerwing and Uhl, 2002 and Alvira *et al.*, 2004). This treatment was intended to improve tree growth where climber-cut trees showed growth rates

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Foresters, however, see climbers as nuisance because they complicate harvesting operation by intertwining and interconnecting crowns and stems of surrounding trees. The presence of climbers on harvest trees also increased felling damages and canopy gaps during timber extraction (Putz, 1984; Appanah and Putz, 1984; Putz, 1985; Putz and Chai 1987 and Pérez-Salicrup *et al.*, 2001b). Climbers which attach to fallen trees could resprout and reinvade the forest rapidly due to their unique stem cells and climbing mechanisms (Putz, 1983, 1984 and 2006; Ewers *et al.*, 1990; Ewers and Fisher, 1991; Pinard and Putz, 1994; DeWalt *et al.*, 2000 and Schnitzer and Bongers, 2002). In addition, climbers impede tree growth, regeneration and productivity by competing with trees for water, nutrients and, light (Stevens, 1987; Pérez-Salicrup and Barker, 2000; Pérez-Salicrup, 2001; Gerwing, 2001 and Grauel and Putz, 2004).

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Although climber cutting can reduce harvesting damage, the cost of implementing climber cutting is expensive (Liew, 1973a; Appanah and Putz, 1984; Vidal *et al.*, 1997; Gerwing, 2001; Pérez-Salicrup *et al.*, 2001b; Parren and Bongers, 2001). For instance, the cost of climber cutting was reported to be US\$6.50 ha^{-1} in low climber density (248 stems ha^{-1}) and increased to US\$28 ha^{-1} in high climber density area (1612 stems ha^{-1}). In view of the high cost, there is reluctance to implement blanket climber cutting (Liew, 1973a). In order to overcome this problem, partial or selective climber cutting has been recommended as alternative to blanket climber cutting (Liew, 1973a; Cedergen, 1996; Pérez-Salicrup *et al.*, 2001a; Bongers *et al.*, 2002; Schnitzer and Bongers, 2002; Grauel and Putz, 2004; and Gerwing, 2006).

In consideration of all the above issues, this study is aimed at investigating the efficiency of selective climber cutting against the standard practice of blanket removal of climbers in tropical forest.

1.2 Objective

The specific objectives of this research are to investigate;

a. the time and cost involved in blanket and selective climber cutting
b. the regenerative capacity of cut climbers (number of resprouting climbers);
c. the growth rate of Potential Crop Trees (PCT) (i.e. 5≤30 cm DBH) after removing climbers.

1.3 Justification

Total removal of climbers or blanket climber cutting in production forests is unnecessary because it could disrupt forest functioning, ecosystem and biodiversity as well as expensive to do. Hence, eliminating climbers selectively was investigated in this thesis. This modification is in line with Principle 21 of the International Tropical Timber Organization's (ITTO) guidelines for Sustainable Management of Natural Tropical Forest, which stressed that harvesting operations should accommodate silvicultural concept that promotes residual stand and natural regeneration growth without disrupting the environment (ITTO, 1992).

Climbers are undeniably possessing vital ecological roles in the tropical forests. Out of ten woody species in the forests, three to four of them were climbers (Muthuramkumar and Parthasarathy, 2001; Nabe-Nielsen, 2001; Schnitzer and Bongers, 2002; Putz, 2006 and Senbeta *et al.*, 2005). This number, however, is likely to change when climbers were removed entirely. In Bolivia, for example, liana density was reduced to 95% or 130 stems ha^{-1} immediately after cutting (Pérez-Salicrup *et al.*, 2001a). Similarly, a reduction of 55% or 130 stems ha^{-1} was reported following climber cutting (Gerwing and Vidal, 2002). Hence, in performing blanket climber cutting, more than half of the climbers in the forest were eliminated.

Total removals of climbers also affect the functioning of the forests with respect to transpiration and carbon sequestration. Climbers are known to have high rates of water flux and transpiration because of their slender stems embedded with long and wide vessels (Putz, 1983; Ewers *et al.*, 1990 and Ewers and Fisher, 1991). Hence, if climbers were totally removed, forest transpiration would reduce by approximately 9-12% of the total transpiration i.e. 5.4 mm d^{-1} (Restom and Nepstad, 2001). In terms of forest carbon stock, blanket climber cutting would diminish the stock by 23 t ha^{-1} (Gerwing and Farias, 2000). If only 20% of the total climber stems were removed, this would only retain 0.08 mm d^{-1} of forest transpiration and 4.6 t ha^{-1} of carbon stock.

Climbers are sources of medicine and food for people and wildlife. They also provided habitat and intercrown pathways for the arboreal animals and insects (Emmons and Gentry, 1983; Dudley and DeVries, 1990; Woon and Lau, 1994; Blüthgen and Fiedler, 2002 and Bongers *et al.*, 2002). Total elimination of climbers will diminish these sources and may lead to migration or mortality of arboreal animals and insects. On the other hand, locals or villagers might utilize other forms of vegetations or wildlife as food and medicine that may lead to extinction in the forest due to scarcity of required climbers. As a consequence, these cases may upset the biodiversity value and ecosystem of the forest.

The cost of climber cutting in the tropical countries was expensive ranging from US$1 ha^{-1} to US$15 ha^{-1} (Liew, 1973a; Vidal *et al.*, 1997; Parren and Bongers, 2001; Gerwing, 2001; Pérez-Salicrup *et al.*, 2001b; Pérez-Salicrup, 2001 and Grauel and Putz, 2004). To reduce the cost of climber cutting, one option would be to cut only climbers that are attach to harvestable trees (Liew, 1973a; Cedergen, 1996; Pérez-Salicrup, 2001; Pérez-Salicrup *et al.*, 2001b; Schnitzer and Bongers, 2002; Grauel and Putz, 2004; Putz, 2006; Gerwing, 2006). In doing so, it had been reported that it could save 73% of the cost (Liew, 1973a).

Climbers should be eliminated particularly prior to logging because it had been proven to reduce harvesting damage and promote timber growth. However, they should be eliminated selectively as they possessed vital roles in the forest. Study regarding selective removal of climbers is still limited, and this study is intended to narrow this information gap. The efficiency of climber cutting is measure by time taken, regeneration of climbers and tree growth response between treatments.

1.4 Hypotheses

It is hypothesized that adopting selective climber cutting would be as effective as blanket climber cutting in terms of climbers' mortality and cost leading to a higher growth of Potential Crop Trees (PCT). The hypotheses for this study are formulated as follows:

a. Hypothesis 1

H_{0} = There is no significant difference in the cost between blanket and selective climber cutting.

H_{A} = There is a significant difference in the cost between blanket and selective climber cutting.

b. Hypothesis 2

H_{0} = There is no significant difference in climbers' regeneration between blanket and selective climber cutting.

H_{A} = There is a significant difference in climbers' regeneration between blanket and selective treatment climber cutting.

c. Hypothesis 3

$H_0 =$ There is no significant difference in the growth rate of PCTs between blanket and selective climber cutting.

$H_A =$ There is a significant difference in the growth rate of PCTs between blanket and selective climber cutting.

The above null hypotheses are accepted if the calculated statistics are greater than the 5% significance level ($p>0.05$). On the contrary, the above alternate hypotheses were to be accepted if the calculated statistics are lower than the 5% significance level ($p<0.05$).

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution of Climbers

Climbers constitute approximately a quarter of the woody species density and diversity in tropical forest (Muthuramkumar and Parthasarathy, 2001; Nabe-Nielsen, 2001 and Schnitzer and Bongers, 2002). In Sabah, climber density can range from 189 to 1348 stems ha^{-1} with species richness ranging from 40 to 104 species (Cedergren, 1996; Campbell and Newberry, 1993 and DeWalt *et al.*, 2006). Climber density and species richness, generally, are influenced by geographic locality (e.g. latitudinal and altitudinal gradient), abiotic factors (e.g. total rainfall and seasonality of rainfall and soil fertility), biotic factors (e.g. host-tree architecture) and disturbances.

2.1.1 Geographic Location

Geographic location plays an important role in species richness, density and distribution of tropical climber species. Generally, climbers are not suited to high latitudes and elevation (Balfour and Bond, 1993; Schnitzer and Bongers, 2002; Parthasarathy *et al.*, 2004; Molina-Freaner *et al.*, 2004; Schnitzer, 2005 and Jiménez-Castillo *et al.*, 2007). Cold climate would induce cold embolism to the climbers and terminated their vascular system (Ewers, 1985; Sperry *et al.*, 1987; Ewers *et al.*, 1997 and Schnitzer, 2005). Consequently, this condition constrained their growth and eventually destroys them when freezing prolonged (Ewers *et al.*, 1997; Fisher *et al.*, 1997 and Schnitzer, 2005).

Climbers tend to be high in abundance and diverse at areas close to the equator (Schnitzer and Bongers, 2002, Molina-Freaner *et al.*, 2004 and Schnitzer, 2005). Jiménez-Castillo *et al.* (2007) reported that the number of climbers increases from 1% to 17% when latitude decreases from 36° to 20°. Climber species richness presented the same trend increasing from 10% to 25% from temperate to lowland tropical zones (Schnitzer and Bongers, 2002). Hence,