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Influence of rattan (*Calamus merrilli* Becc) dominance on regeneration status of native and exotic trees in a secondary forest

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Abstract

Second growth forest are widely considered as playing important roles in the livelihoods of local people in the Philippines providing non-timber forest products like rattan, for subsistence use or as a source of income. However the impact of rattan dominance to the succession of native and exotic seedling is not yet fully understood. This paper aims to determine the influence of rattan growing vigorously in a secondary forest and investigate how rattan dominance influence the regeneration status of native and exotic tree species, compare the regeneration status in presence of rattan and to analyze the relationship of rattan dominance to different environmental factors. Result shows that rattan dominance implies adverse effects on seedlings which influenced the succession of some native and exotic seedlings. Furthermore, a rattan growing vigorously in an understory has a greater impact on regeneration status of second growth forest due to a possible understory competition.

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Introduction

In tropical countries, forests are widely considered as playing important roles for livelihood of local people, providing non-timber forest products for subsistence use or as a source of income (Arnold & Ruiz Perez, 2001; Ndangalasi *et al.*, 2007). In developing countries, rattan is an important non-wood forest produce after timber (Meitram & Sharma, 2005; Ros-Tonen, 2000; Sastry, 2002), and the most commercially important non-timber forest products extracted from tropical forests, being used as a raw material in furniture and handicraft industries. (Dransfield & Manokaran, 1994; Rachman & Jasni, 2006). Economically, rattans are used extensively for furniture, basket making and construction making them valuable non-timber forest product (Sastry, 2002). Rattan species, which is mostly straggling or climbing spiny-palm with characteristic of scaly fruits, is a versatile plant belonging to family Arecaceae/Palmae and subfamily Calamoideae (Belcher, 1999). Rattan is widely distributed in tropical Asia, from the Indian sub-continent to Southeast Asia, and is also found in Africa and subtropical eastern Australia (Sunderland & Dransfield, 2002).

Rattans are climbing plants and are structurally dependent on trees and proliferate in disturbed environment (Laurence, 1999; Siebert, 1993; Putz, 1990). Fragmented forest supported higher abundances of rattans than intact forest but how rattans respond to forest fragmentation has yet to be explored (Campbell, 2017). But according to Campbell the response of wild population of rattan to the simultaneous alteration of multiple environmental traits is imposed by fragmentation. However individual environmental traits are known strongly influence rattan abundance (Campbell, 2017). In general, rattan abundance increases in moderate to high light conditions (Siebert, 2002), in well-drained soil (Siebert 2002; Dransfield, 1992). However, species-specific rattan responses have been identified for light-availability, soil type, elevation and soil moisture (Siebert, 2012; Thonhofer, 2015). Previous studies have reported on the ecological impacts of rattan cane harvesting (Evans, 2002; Palis, 2004; Siebert, 2002; Sunderland & Dransfield, 2002). Siebert (2002, 2004) describes rattan harvesting having an impact on second growth forest, as logs are used to build rafts for transporting the canes along rivers. However, this is not a widespread method of transport, as farmers commonly carry harvested canes along rails out of the forest for instance, similar practice done in the study sites. Better understanding on the influence of rattan dominance in a secondary forest is needed in order to determine whether this problem is in conflict with forest conservation interests, or can be part of sustainable practice, which protects the secondary forest and its ecosystem services while also providing an important source of income for local livelihoods. In this study, we hypothesized that the presence of rattan implies adverse effects on seedlings (i.e. no. of species, density and height). Also, we assumed that the environmental factors (i.e. light transmission, canopy openness and soil moisture) have no influenced to treatments, but rather attributed to an understory competition between rattan plants and the tree seedlings (Widayati, 2012).

Furthermore, the aim of this study is to determine the influence of rattan growing vigorously in a secondary forest of Central Mindanao University, Musuan, Maramag, Bukidnon. The specific objectives of this study are (1) to investigate how rattan dominance influence the regeneration status of native and exotic tree species; (2) to compare the regeneration status in present of rattan and without rattan areas and (3) to analyze the relationship of rattan dominance to different environmental factors such as light transmission, canopy openness and soil moisture.

Materials and methods

Locale of the Study

The study was conducted in a mixed secondary forest fronting the administration building of College of Forestry and Environmental Science, Central Mindanao University, Musuan, Maramag, Bukidnon Geographically, located at 7˚51' 35''N latitude and 125˚2' 49''E longitude.

The elevation of the area ranges from 300-360 meters above sea level. The general climate of the area falls under Type III based on the Modified Corona classification of PAGASA characterized as having a seasonal variability that is not very well pronounced, with a dry season from November to April and wet during the remaining months of the year.

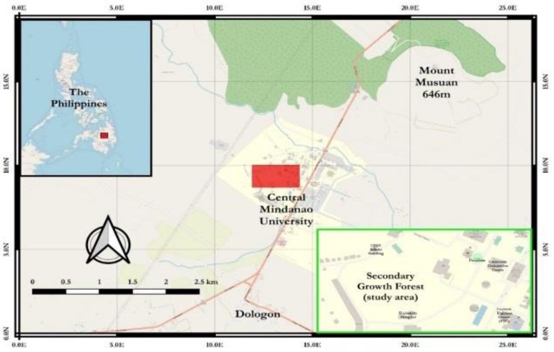

Fig. 1. Map of the study area.

Sampling plots and Measurement

Field inventory was conducted in second growth forests where rattan is growing vigorously in the understory a total of 28 (3x3m) sampling plots were established and divided into 14 plots with the presence of rattan and without rattan as a treatment. The plots were determine using opportunistic sampling by selecting 10 meters away from the previous plot. Plots were measured, marked with sticks and the following information regarding the regeneration status of native and exotic trees were recorded and accounted: species, number of individuals (seedlings) and The Mueller-Dombois (1974) formula was used to determine the density.

Density (*D*) = number of individuals of the species.

Fig. 2. Representative hemispherical photos of the four canopy treatments within a regenerating secondary forest at Central Mindanao University, Musuan, Maramag, Bukidnon: A) With rattan B) Without rattan.

Hemispherical photographs were used to quantify differences in understory light transmittance among treatments. The photographs were taken in 2019 at the center of each plot during overcast skies using a digital camera (Nikon Coolpix 5400, Japan) with a fish-eye lens (FC-E9 Nikon, Japan). The camera was set up at 1.37m aboveground, with the lens positioned vertically, and the top of the resulting image orientated to the north. Estimation of percent light transmission from the hemispherical photos was accomplished using Gap Light Analyzer (GLA version 2; Frazer *et al.* 1999). In the GLA modeling, the growing season was specified from 1 March to 31 October to match estimated local plant growth patterns. Furthermore 300 grams of soil was collected in each plot with a depth of at least 30cm and oven dried for at least 8 hours to test for soil moisture.

Data Analysis

All statistical analyses were performed using R software (R Core Team 2019). Different R packages were used (i.e. rstatix, car, and broom) for one-way multivariate analysis of variance (MANOVA) to quantify all the data sets (no. of species, density, average height, light transmission, canopy openness and soil moisture) and Wilks Lambda was then used as test statistic for computing MANOVA. Likewise, the relationships among parameters were analyzed with Pearson's correlation test. Follow-up univariate

ANOVA was also used to further test the data sets. Finally, Games-Howell post hoc test was then used for multiple pairwise comparisons.

Results and discussion

Density of seedlings

A total of three (3) species were recorded in plots without presence of rattan, the highest number of seedlings were *Sweitenia macrophylla* (Meliaceae) followed by *Tectona grandis* (Lamiaceae) and *Artocapus blancoi* (Moraceae). While five (5) species were recorded in plots with presence of rattan, the highest number of seedlings were *Sweitenia macrophylla* (Meliaceae) followed by *Gmelina arborea* (Lamiaceae), *Tectona grandis* (Lamiaceae), *Artocapus blancoi* (Moraceae) and *Parashorea malaanonan* (Dipterocarpaceae) most species identified were exotic because some native species were already in their pole stage (i.e. *Shorea contorta*). The presence of rattan greatly influences the density of seedlings both native and exotic tree species (Fig. 3). Using Pearson's correlation results revealed that there was a weak relationship in treatment A (with rattan) compare to treatment B (without rattan) to the combined dependent variables, indicates that the presence of rattan influence the regeneration status of native and exotic species (Fig. 4).

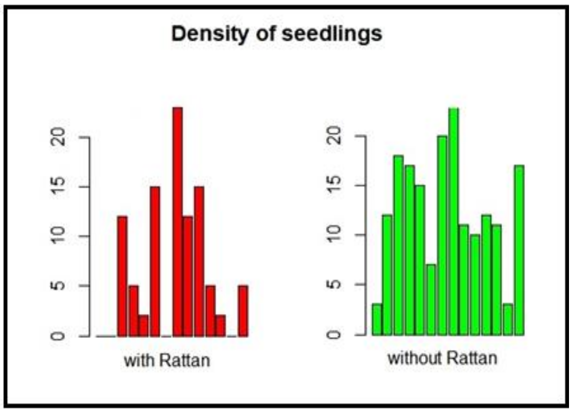

Fig. 3. Shows the total density of seedlings/9 sq.m in all sampling plots (with and without rattan plots).

The different variables (i.e. Average height, Canopy Openness, Density, Light transmission, No. of species and Soil moisture) assessed within sample plots shows varying mean and standard deviation among treatments (Table 1).

Table 1. Mean and standard deviation within sample plots. woR = without rattan, and wR = with rattan.

Treatment	Variable	N	Mean	SD
1 woR	A_height	14	14.1	2.76
2 woR	CanOp	14	12.2	2.63
3 woR	Density	14	12.8	5.98
4 woR	LightTrans	14	8.15	1.46
5 woR	n_species	14	2	0.784
6 woR	Smoist	14	26.1	11.4
7 wR	A_height	14	11.7	8.26
8 wR	CanOp	14	10.8	2.46
9 wR	Density	14	6.86	7.29
10 wR	LightTrans	14	6.85	2.32
11 wR	n_species	14	1	0.877
12 wR	%Smoist	14	31.7	12.0

Table 2. Shows the most highly correlated between dependent variables in each treatment, as assessed by Pearson's correlation. A = with rattan plots and B = without rattan plots.

Most highly correlated							
A. with rattan plots				B. without rattan plots			
No	First variable	Second variable	Correlation	No	First variable	Second variable	Correlation
1	LightTrans	CanOp	0.831	1	LightTrans	CanOp	0.882
2	CanOp	Smoist	-0.386	2	n_species	Density	0.745
3	Density	LightTrans	0.383	3	LightTrans	Smoist	-0.669
4	Density	A_height	-0.368	4	n_species	A_height	0.641
5	n_species	CanOp	0.335	5	CanOp	Smoist	-0.579
6	n_species	A_height	-0.307	6	Density	A_height	0.552
7	LightTrans	Smoist	-0.136	7	Density	Lightrans	0.471
8	A_height	Smoist	-0.124	8	Density	Smoist	-0.401
9	A_height	CanOp	-0.12	9	Density	CanOp	0.369
10	Density	Smoist	0.0983	10	n_species	Smoist	-0.277
11	A_height	LightTrans	-0.0734	11	A_height	Smoist	-0.264
12	Density	CanOp	0.0717	12	n_species	CanOp	0.219
13	n_species	Density	0.0656	13	n_species	LightTrans	0.181
14	n_species	LightTrans	0.0585	14	A_height	CanOp	0.128
15	n_species	Smoist	-0.0133	15	A_height	LightTrans	0.0719

For computing the MANOVA, Wilks test statistic revealed that there were no significant differences among treatments on the combined dependent variable F (6, 21) = 1.7871, p <0.05 (Table 3.) therefore, the null hypothesis has been retained.

Table 3. Results shows that there were no statistically significant differences among treatments on the combined dependent variables (no. of species, Density, Average height, Light transmission, Canopy Openness and Soil moisture).

Type II MANOVA Tests: Wilks test statistic
Df test stat approx. F num Df den Df Pr(>F)
Treatment 1 0.66199 1.7871 6 21 0.1505

To test further the results in computing of MANOVA, a follow up univariate ANOVA examining separately, each dependent variable was used. As the studies have six (6) dependent variables, we need to apply Bonferroni multiple testing correction by decreasing the level we declare statistical significance.

This is done by dividing classic alpha level (0.05) by the number of tests. This leads to a significance acceptance criterion of P < 0.0083 rather than P < 0.05 and revealed that there were no significant differences in Average height (F(1, 26) = 1.06, P <0.0083), Canopy Openness (F(1, 26) = 2.04, P <0.0083), Density (F(1, 26) = 5.53, P <0.0083), Light transmission (F(1, 26) = 3.14, P <0.0083), No. of species (F(1, 26) = 10.1, P <0.0083), and Soil moisture (F(1, 26) = 1.62, P <0.0083) among treatments (Table 3).

Table 4. Follow-up univariate ANOVAs, using a Bonferroni adjusted alpha level of 0.0083, showed that there were no statistically significant differences among treatments and combined dependent variables.

Variables	Effect	DFn	Dfd	F	p	`p<.00083`	ge
1 A_height	Treatment	1	26	1.06	0.31	ns	0.0393
2 CanOp	Treatment	1	26	2.04	0.16	ns	0.0735
3 Density	Treatment	1	26	5.53	0.02	ns	0.1757
4 LightTrans	Treatment	1	26	3.14	0.08	ns	0.1088
5 n_species	Treatment	1	26	10.1	0.00	ns	0.284
6 Smoist	Treatment	1	26	1.62	0.21	ns	0.0585

All pairwise comparisons between treatments were not significant for each of the dependent variables (no. of species, density, average height, light transmission, canopy openness and soil moisture).

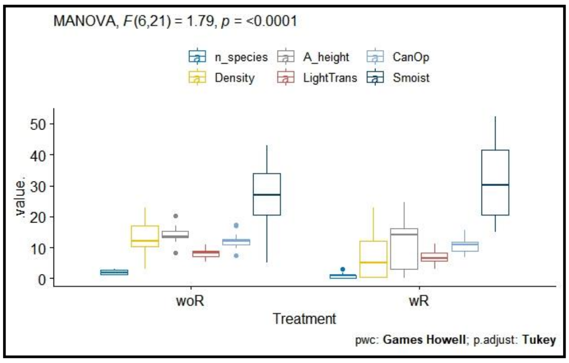

Fig. 4. Shows all pairwise comparisons for each dependent variable within treatments.

The Wilks test statistic results presented in (Table 3) shows that there were no significant differences among treatments. Suggesting that presence of rattan implies adverse effects only on seedlings in terms of no. of seedlings presence, density and height in the study area and environmental factors such as light transmission, canopy openness and soil moisture have no influenced to treatments. This study further support the previous study of Widayati, (2012) that rather than environmental influences but a possible understory competition between rattan and seedlings. Pearson's correlation test shows that there was a weak relationship in treatment A (with rattan) which greatly affects the regeneration of native and exotic seedlings compare to treatment B (without rattan).

Forest disturbance drives an increase in rattan abundance. For instance, fragmentation in an area due to human activities, improper plantation management of non-timber forest product has resulted in significantly higher total rattan abundance and also promotes environmental or ecological changes which favor this climbing plant. The proliferation of rattans in response to forest fragmentation is similar to that found for woody-dicotyledonous lianas and suggests that fragmentation promotes environmental or ecological changes which favor both types of climbing plants (rattans and lianas) (Campbell, 2017). Furthermore, previous study revealed that within forest fragments, light availability had a significant positive influence on rattan abundance. Sites with lower canopy cover had greater total, adult and juvenile rattan abundance than sites with high canopy. Light is the most important determinant of rattan species composition, densities and growth rates for South East Asian communities (Siebert, 2012). However, the study site is in high canopy but still rattan is growing vigorously in understory which suggest that belowground competition is higher which affect the succession of the second growth forest.

Conclusion

It is highly concluded that the rattan growing vigorously in an understory have a greater impact to a succession in a second growth forest due to an understory competition which meet the assumption of the study. It is recommended to further study on below ground competition to understand more the influence of rattan growing in a second growth or primary forest. This present study will also serve as a base line for future researches on the country.

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