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Survival and Growth Rate of Several Climax Species of Tree in Tropical Rains Forest Ulu Gadut West Sumatra Indonesia

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Abstract: Long-term study of the growth of a forest stand is needed in order to conserve tropical forests. We have been monitoring the survival and growth of six species of climax (*Cleistanthus glandulosus*, *Hopea dryobalanoides*, *Mastixia trichotoma*, *Microcos florida*, *Nephelium juglandifolium* and *Swintonia schwenkii*) in Ulu Gadut tropical rain forest, West Sumatra, 32-year period (1981-2013). The average of Relative Diameter Growth Rate (RDGR) for six species ranged from 0001-0028 cm year^{-1} with a survival rate of 46.15-86.67%. There was a significant difference in the growth of each species (f = 2,613; $p<0.05$, Scheffe *post-hoc* test). Growth of *Trichotoma mastixia* and *Microcos florida* were faster than other species. This indicated that the second species was the determinant of the sustainability of tropical rain forests in Ulu Gadut in the future.

Key words: Climax species, relative diameter growth rate, survival, tropical rains forest, Ulu Gadut West Sumatra

INTRODUCTION

Growth is one of the determinants for tropical forest dynamics. Many factors affect the growth of tropical forests such as the availability of water, nutrients and light (Toledo *et al.*, 2011), rainfall (Murphy and Lugo, 1986; Dauber *et al.*, 2005), drought (Yoneda *et al.*, 2000; Da Costa *et al.*, 2010) and the soil's fertility (Russo *et al.*, 2005). Climate is a moving factor for spatial variation of forest stands growth (Toledo *et al.*, 2011).

Ulu Gadut forest area is a part of the tropical forest which located in the ranks of Bukit Barisan in West Sumatra, Indonesia. Ulu Gadut forest area as a whole covered with trees and vegetation distribution varies from the foothills to the peaks. This causes growth stands become diverse, there is growing relatively fast or vice versa.

Long-term study associated with the condition of tropical forests in Ulu Gadut region has started since 1980 (Yoneda *et al.*, 1990, 1994, 2000, 2006; Mukhtar *et al.*, 1992, 1998; Kohyama *et al.*, 1994; Hermansah *et al.*, 2002). Some important information relating to the condition of forest ecology Ulu Gadut have obtained through the use of inventory permanent plot data, all information generated is still in a state of partial short time. Conditions for growth and survival rate stands climax species in particular, there has been no information, so studies stand growth and survival rates are needed climax species as a determinant of the sustainability of tropical forest in the Ulu Gadut future. The study aims to determine the survival and growth rates of six species of climax in the tropical forests of West Sumatra Indonesia.

MATERIALS AND METHODS

Description of research sites: Field study was carried out at a 1 ha plot, Pinang Pinang Plot (PIN) in a foothill rainforest of Mt Gadut of 1859 m above sea level (asl) West Sumatra, Indonesia. The plot consisted of 115 subquadrats and extended from 575-605 m asl (0° 55' S, 100° 30 'E) (Fig. 1). Pinang-Pinang plots are based on collaboration of Andalas University with Japan International Cooperation Agency (JICA) which was incorporated in an activity of Sumatra Nature Study (SNS: Botany) in 1981. Ninety-one and 67% of the initial registered trees were identified to the genus and species level, respectively and Hotta (1984) estimated the total number of tree species over 8 cm as 304. Fagaceae had the highest basal area dominance, accounting for 18% of initial total and *Swintonia schewenckii*, Anacardiaceae was abundant in the emergent layer with a maximum height of 59 m.

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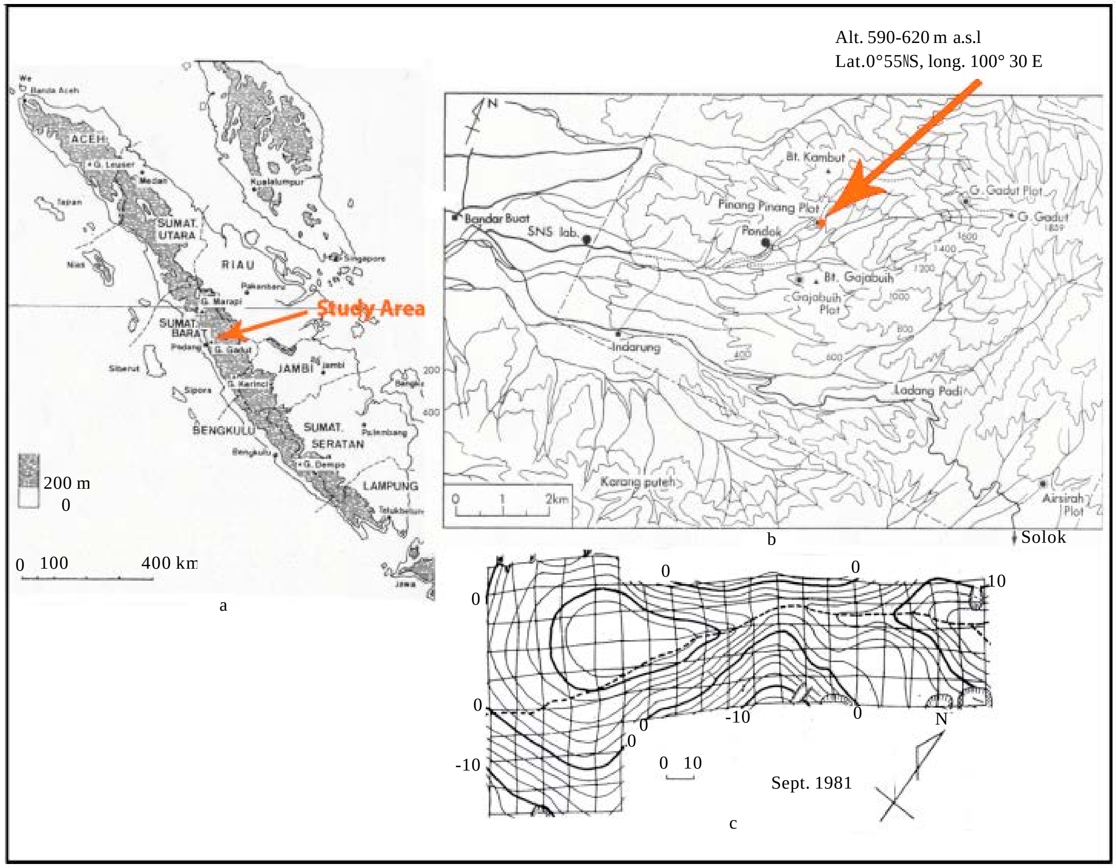

Fig. 1(a-c): Location of study area at Pinang-Pinang Plot, Padang, West Sumatra, Indonesia, (a) Map of Sumatra, (b) Map of Mt Gadut area and (c) Topographycal map of Pinang Pinang Plot

Aboveground biomass and net primary production of this stand were estimated as 414 and 20 Mg ha^{-1}, respectively (Yoneda *et al*., 1994).

In general, this area belongs to the area with a wet tropical climate type. Relatively high annual rainfall. By recording of BMKG (2012), Padang noted that the highest rainfall in 2011 was 826 mm in November and the lowest was 118 mm in May. The average monthly temperature was 24.8-27.3°C and found no dry season. Soil conditions were generally very heterogeneous with soil pH H_2O on the horizon A ranged from 3.69-5.55.

Data collection: Objects used in this study were data of repeatly measuring result in Pinang-Pinang Plots, Ulu Gadut West Sumatra. Data of diameter at breast height (dbh) were obtained from forest ecology and flora of *G. gadut* West Sumatra (Hotta, 1984), showed that measurement resulted in 1981 while data for 2013 were obtained from measurements at the time of the study. Census inventory of measurement data were limited to 6 species based on dominance in the year of 2013. All six species were *Mastixia trichotoma*, *Microcos florida*, *Cleistanthus glandulosus*, *Hopea dryobalanoides*, *Nephelium juglandifolium* and *Swintonia schwenkii*. Stages of study included measurement of the character of stand structure, drafting of table stand structure based on the number of trees per class of diameter, counting of life survival rate and average of Relative Diameter Growth Rate (RDGR). Measurements of stand structure characteristics such as density and basal area were calculated according to Mueller-Dombois and Ellenberg (1974) for census 1981 and 2013. Measurement of the percentage of survival rate was measured by dividing the number of target species that lives up to the end of the census with the number of target species at the beginning of the census. The RDGR was estimated based on the results of the increasing of stand dbh, inventory result of census data in 1981 and 2013 by using the formulation Kohyama and Hotta (1986).

Analysis of data: Statistical analysis of One-way ANOVA used Scheffe *Post-hoc* test to compare the difference in average of increasing basal area, dbh and growth inter species during 1981-2013 period with 5% confidence interval. Data analysis was performed by using computing program and SPSS version 16.

RESULTS

Survival rate: Dynamics characteristics of stands for six species of climax were presented in Table 1. Variations of stands density in 2013 ranged from 13-21 ind ha^{-1}, basal area 0.523-3.390 m^2 ha^{-1}. Total density and basal area for *Hopea dryobalanoides* were 14 ind ha^{-1} and 1.037 m^2 ha^{-1}, basal area increased to 0.508 m^2 ha^{-1} (96.03%) compared with in 1981. *Cleistanthus glandilosus* was of 13 ind ha^{-1} and 0.523 m^2 ha^{-1}, basal area was decreased of 0.094 m^2 ha^{-1} (15.24%). *Mastixia trichotoma* was of 14 ind ha^{-1} and 0.821 m^2 ha^{-1}, basal area increased to 0.275 m^2 ha^{-1} (50.37%) (Table 1). There was a significant difference to the increasing of basal area among six species between 1981 and 2013. The highest increasing of basal area encountered on *Nephelium juglandifolium* of 1.987 m^2 ha^{-1} (141.63%) with stands density of 15 ind ha^{-1} while the largest decreasing in the basal area was observed on *Swintonia schwenkii* of 2.258 m^2 ha^{-1} (55.45%) from 1981 (One-way ANOVA, f = 7052, p<0.05, Scheffe's *post-hoc* test).

The survival rate for all species ranged between 46.15-86.67% in the 1981-2013 intervals. The highest survival rate was observed in *Nephelium juglandifolium* (86.67%), followed by *Hopea dryobalanoides* and *Microcos florida* were 80.00 and 69.57%, respectively. And the lowest was 46.15% for *Swintonia schwenkii.* In addition, the percentage of deaths among species was higher than recruitment. Percentage of death and the highest recruitment found on *Mastixia trichotoma* and *Hopea dryobalanoides* 3.17 and 1.85%, respectively (Table 1).

Growth rate: Number of individuals based on the distribution of diameter size frequencies (dbh) for each species in 1981 and 2013 was shown in Fig. 2. For *Hopea dryobalanoides*, *Microcos florida, Swintonia schwenkii*, the most individual number in 2013 was observed at diameter size 10.1-20.0 cm. *Cleistanthus glandilosus* and *Mastixia trichotoma* were at 20.1-30.0 cm diameter in size and *Nephelium juglandifolium* in diameter size was above 50 cm.

Standard dbh observations showed an increasing of growth during the observation period. Total elevating in the average of dbh in 1981 and 2013 for six species was 11.34±9.60 cm at the end of the census (2013). There was significant difference in the average of dbh increasing for all six species (One-way ANOVA, f = 2, 613, p<0.05, Scheffe *post-hoc* test). The highest increasing in dbh found in *Nephelium juglandifolium* of 17.85±14.53 and then followed by *Swintonia schwenkii* 18.59±12.68 and the lowest dbh was at *Cleistanthus glandilosus* at 4.4±3.04 (Table 2).

Relative growth rate of species based on diameter increment (RDGR) of 0.013±0.001 cm $year^{-1}$ (mean±SE). RDGR for *Cleistanthus glandulosus* was 0.007±0.02, *Hopea dryobalanoides* was 0.012±0.01, *Mastixia trichotoma* and *Microcos florida* were 0.017±0.02, *Nephelium juglandifolium* was 0.014±0.02 and *Swintonia schwenkii* was of 0.009±0.01, respectively. The highest RDGR found in *Mastixia trichotoma* and *Microcos florida.* Based on statistical analysis one-way ANOVA using Scheffe's *post-hoc* test found significant differences between RDGR of *Mastixia trichotoma* and *Microcos florida* with *Cleistanthus glandilosus* (f = 4, 237, p<0.05, Fig. 3).

Table 1: Structural dynamics characteristics of the climaxs species on permanent plots Pinang-pinang (1 ha)

	1981		2013		Survival rate (%)		
Species	N	BA (m^2 ha^{-1})	N	BA (m^2 ha^{-1})	Rate	M	R
Hopea dryobalanoides	10	0.529	14	1.037	80.00	2.81	1.85
Cleistanthus glandilosus	19	0.617	13	0.523	47.37	2.31	0.60
Mastixia trichotoma	20	0.546	14	0.821	60.00	3.17	1.56
Microcos florida	23	0.501	21	0.973	69.57	1.33	0.73
Nephelium juglandifolium	15	1.403	15	3.390	86.67	0.23	0.42
Swintonia schwenkii	13	4.559	13	2.031	46.15	0.82	0.65

N: Density of stands (ind ha^{-1}), BA: Basal area ((m^2 ha^{-1}), M: Mortality (%), R: Recruitment (%)

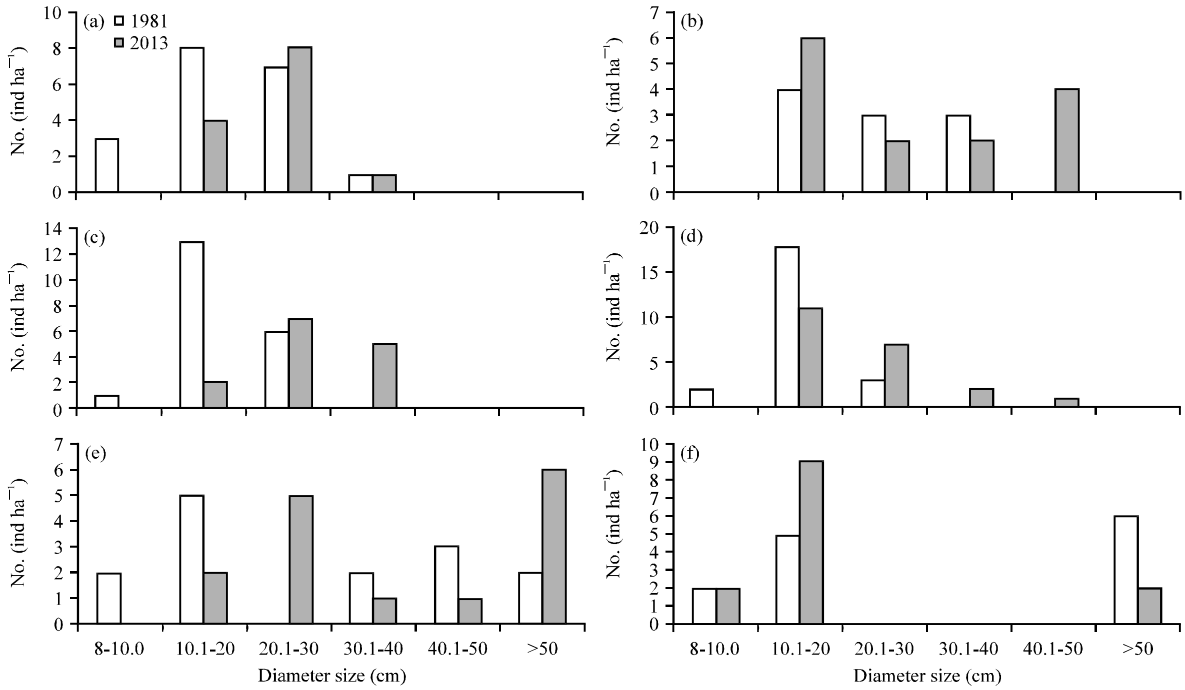

Fig. 2(a-f): Frequency distribution of dbh (cm) of each species by diameter size in 1980 and 2013, (a): *Cleistanthus glandulosus,* (b): *Hopea dryobalanoides*, (c): *Mastixia trichotoma,* (d): *Microcos florida*, (e): *Nephelium juglandifoiium* and (f): *Swintonia schwenkii*

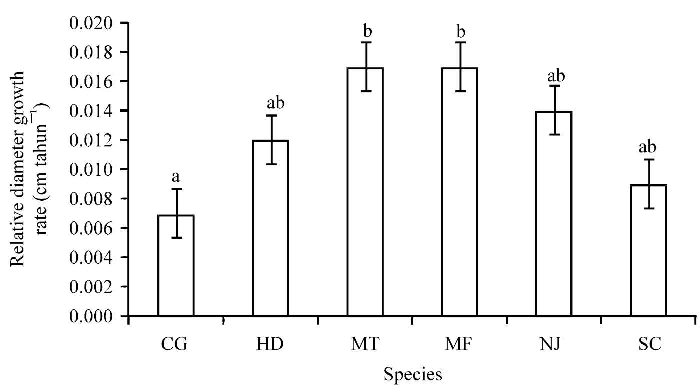

Fig. 3: Relative Diameter Growth Rate (RDGR) (cm year^{-1}) for six climax species, Relative Diameter Growth Rate (RDGR) (cm year^{-1}) for species *Cleistanthus glandulosus* (CG), *Hopea dryobalanoides* (HD), *Mastixia trichotoma* (MT), *Microcos florida* (MF), *Nephelium juglandifolium* (NJ) and *Swintonia schwenkii* (SC) in permanent plots Pinang-Pinang Rainforest Ulu Gadut West Sumatra, with Error Barr Standard Error (± 0.001 SE 0:01; one-way ANOVA, f = 4,237, p>0.05, Scheffe *post-hoc* test)

DISCUSSION

Variations of character structure for six climax species in the tropical rainforest was signed by the increasing and decreasing of density and basal area lapse period from 1981-2013. The high density of species did not guarantee an elevation of stand basal area. For example *Microcos florida* had the highest density between other species but not for basal area which was lesser than *Nephelium juglandifolium*. According to Muhdin *et al.* (2008), the number of trees and stand structure could reflect the availability of stand at every level of growth.

Table 2: Comparison of the average increasing of dbh (cm) for six target species during the 32-year interval based on species that lives up to the year 2013 using Oneway ANOVA and post hoc Scheffe Test

Spesies	Range	Average ±SD
Cleistanthus glandilosus	0.40-9.70	4.41±3.04[a]
Hopea dryobalanoides	6.80-16.30	10.13±2.89[ab]
Mastixia trichotoma	6.50-16.70	11.46±3.12[ab]
Microcos florida	2.80-23.70	10.41±5.13[ab]
Nephelium juglandifolium	2.00-46.40	17.85±14.35[b]
Swintonia schwenkii	2.70-50.20	12.68±18.59[ab]
Total		11.34±9.60
f-value		2.613
Significant		*

Mean±SD with different superscript letters indicated significant differences in dbh increased ($p<0.05$) between species and the same superscript letters were not significantly different

Frequency distribution of diameter size showed that the number of individuals for six species was much more in groups' 10.1-20.0 cm diameter size or there were at stake level in category's Manuri *et al.* (2011). The results of study for each species showed that the number of initial tree (smallest diameter) was very minimal amount (Fig. 2). This means that all six species had a low level of regeneration of stand or not in ideal condition in which the proportion of stands are not distributed proportionately to the largest diameter size.

The survival and the average diameter of growth for each species was a consequence of the response of species to environmental factors, disturbance and competition (Murphy and Lugo, 1986; Toledo *et al.*, 2011). The results showed that there were variations and differences in the growth between species which *Mastixia trichotoma*, *Microcos florida*, the average of growth was faster than other species (One-way ANOVA, f = 4,237, $p<0.05$, Scheffe *post-hoc* test). The discrepancies were possible because of the different responses and adaptations among species to environmental conditions and the disruption caused by the change of climate fluctuations. The difference of growth average was also made possible because of the difference in allometri average, photosynthetic capacity and reproductive allocation (King *et al.*, 2006). Murphy and Lugo (1986) found that there was a relationship of growth with an elevation in heavy rainfall and decreased with increasing of drought (Yoneda *et al.*, 2006). Besides this, the high level of stand density also affected growth indirectly particularly in utilizing of forest resource in Ulu Gadut. But how far the influence of density and environmental factors to the growth of climax species could not be disclosed due to the limitations of the data and information.

CONCLUSION

The Relative Diameter Growth Rate (RDGR) of climax species in tropical forests of Ulu Gadut ranged from 0.013±0.001 cm year^{-1} (mean±SE), with a range between 0001-0028 cm year^{-1}. Survival rate was between 46.15-86.67%. There were significant differences of growth average of each species (f = 2, 613, $p<0.05$, Scheffe *post-hoc* test). *Trichotoma mastixia* and *Microcos florida* was faster than other species. There were differences and similarities of relative growth average between species depending on its response to environmental conditions. The previous conclusion gave a drawing about the survival rate and growth of climax species in tropical forests of Ulu Gadut. Further study is needed to investigate the effect of environmental changing to the dynamics of stand structure for the development of future.

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