The Contribution of Dominant Tree Species to Nutrient Cycling in a Mixed Forest Ecosystem on Mount Tangkubanperahu, West Java, Indonesia

Dian Rosleine, Devi N. Choesin & Endah Sulistyawati
Ecology & Biosystematics Research Group
School of Life Sciences and Technology, Bandung Institute of Technology,
Jalan Ganeca No.10, Bandung 40132, Indonesia

Abstract

The following study was conducted to compare the relative contribution of dominant tree species (Cyathea latebrosa, Astronia spectabilis, and Syzygium spp.) to forest nutrient cycling, by comparing their litter production, nutrient use efficiency (NUE), and litter decomposition rates. Litter production was estimated using the litter trap method; loss in litter mass was determined by the litter bag technique, while NUE was estimated by comparing the amount of litter production to its nitrogen content. The highest litter production was recorded for A. spectabilis, followed by Syzygium spp., and C. latebrosa. The same pattern was observed for litter decomposition rates. The highest NUE was recorded for C. latebrosa, followed by A. spectabilis, and Syzygium spp. Results suggest that species with the highest abundance may not always contribute the most to nutrient cycling.

Keywords : *litter production, nutrient use efficiency (NUE), litter decomposition, Mount Tangkubanperahu mixed forest.*

I. Introduction

Nutrient cycling is a key process in forest ecosystems as it maintains the availability of nutrients for vegetation growth (Rahajoe, 2003; Newbold 1967 in Xu et al., 2003). Three important aspects of forest nutrient cycling are plant litter production, nutrient use efficiency (NUE), and litter decomposition. Litter production constitutes an important flux of organic material into the soil, as it is a source of nutrients reused for plant growth. Litter decomposition rate determines nutrient release from litter to soil, as the nutrients mineralized during decomposition are important for vegetation to produce biomass (Rahajoe, 2003). NUE is an important aspect to be considered because it is indicative of a plant's adaptation to poor nutrient conditions. Plants from poor soils exhibit higher NUE than plants from fertile soil (Vitousek, 1982, 1984). The three aspects mentioned above are all affected by the specific characteristics of plant species.

Dominant tree species play an important role in nutrient cycling through their differing characteristics in producing litter, releasing nutrients, and exhibiting specific chemical composition of litter. Therefore, dominant tree species are important in determining the nutrient status of forest ecosystems (Khiewtam & Ramakhrishanan, 1993, Turreta & Takeda, 1999 cited in Rahajoe, 2003). Although many studies have been conducted to investigate nutrient cycling, there is little information on the contribution of dominant species. Such information is actually important for the maintenance of forest productivity, and forest management in general (Rahajoe, 2003).

The objectives of the following study were to measure the contribution of dominant tree species to nutrient cycling in Mount Tangkupanperahu natural mixed forest, by comparing litter production, nutrient use efficiency (NUE), and litter decomposition characteristics in the three dominant tree species in this ecosystem.

II. Study Site

Mount Tangkubanperahu is located 30 km north of Bandung, the capital city of West Java province. This study was conducted in a mixed natural forest at 2,020 meters above sea level, at 06°45'59" S latitude and 107°36'59" E longitude. Based on its vegetation, this site has been classified as montane zone, characterized by humid and mossy forest (van Steenis, 1972). Mean annual precipitation has been recorded as 2,868 mm, mean temperature ranged between 15–20°C, while relative humidity ranged between 70–90% The characterictic soil is andosol, with color ranging from reddish to brown. Tree vegetation at the site was dominated by *Cyathea latebrosa* (Cyatheaceae family), *Astronia spectabilis* (Melastomataceae family), and *Syzygium* spp. (Myrtaceae family).

III. Sampling Methods

Freshly fallen litter was collected every two weeks from January to April 2006 in three 25 x 40 m^2 plots. Ten litter traps (measuring 50 cm x 50 cm x 10 cm) were placed randomly on the forest floor of each plot. Litterfall was classified into two groups, i.e., litter from dominant tree species and nondominant species. Each group was separated according to plant organ (i.e., leaf, branch, flower, or fruit). All litter were oven dried at 80°C until constant weight and analysed for leaf chemical composition (organic carbon, nitrogen, C/N ratio, lignin, and cellulose).

NUE was estimated by comparing the amount of litter production to nitrogen content in the litter (Vitousek, 1982), as follows:

$$\text{Nutrient use efficiency} = \frac{\text{Litter production (g m-2 yr-1)}}{\text{N}}$$

content in litterfall (g m^{-2} yr^{-1})

Nitrogen content in leaf litterfall was assumed analogous to soil nitrogen.

Litter decomposition rates were estimated by the litterbag method: 50 grams of fresh leaf litter from each dominant species were placed in 48 litterbags (measuring 20 x 20 cm^2 with mesh size 1 cm^2), and placed randomly on the forest floor of three plots. Six bags from each species (i.e., two from each plot) were removed and analysed every two weeks until eight sampling periods. All collected litter were then oven dried at 80°C to constant weight, and data of weight loss in every two weeks were recorded to estimate decomposition rates (Choesin, 1987; Sariyildiz, 2003).

IV. Results dan Discussion

Litterfall Production

Total litter production in the mixed forest ecosystem was 875.82 g m^{-2} yr^{-1}. Leaves constituted the majority of litterfall (74.1%), followed by branch (15.1%), fruit (2.6%), and flower (1.9%). The peak of total litter production was observed at the 28th day of sampling, while the lowest litter production was recorded at the 70th day of the sampling period. Temporal dynamics of forest litter production (Figure 1) suggest that the dynamics of total forest litterfall was affected by dominant tree species; high litterfall production from dominant species increased total liter production, while low litterfall from dominant species decreased total litterfall.

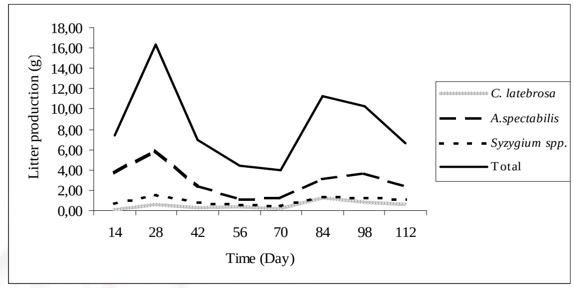

Figure 1. Temporal dynamics of total forest litter production

The contribution of tree dominant species can be shown in Table 1. The largest contribution of litter was recorded from *A. spectabilis*, i.e., 306.53 g m^{-2} yr^{-1}, followed by *Syzygium* spp. (98.53 g m^{-2} yr^{-1}), and *C. latebrosa* (60.01 g m^{-2} yr^{-1}). The contribution from nondominant tree species measured 410.5 g m^{-2} yr^{-1}. The three dominant species contributed more than 53% of the total litter produced, thus suggesting an important role in supplying organic material to be cycled through the forest soil.

Table 1. Litter Production of Three Dominant Species

Species	Litterfall Production		Percentage
	g 0.25m^{-2} per 14 days	g m^{-2} yr^{-1}	(%)
C. latebrosa	0.58 ± 0.39	60.01	6.9
A. spectabilis	2.94 ± 1.56	306.53	35
Syzygium spp.	0.94 ± 0.40	98.53	11.2
Nondominant species	3.94 ± 2.11	410.58	46.9

Nutrient Use efficiency (NUE)

Information on NUE is important as it reflects the plant's strategy in adapting to low availability of soil nutrients. Nutrient efficiency in standing trees can indicate the condition of the soil, where high NUE may indicate low soil nutrient availability (Aerts, 1997; Aerts & Chapin, 2000 cited in Rahajoe, 2003). This study focused on nitrogen use efficiency (NUE_N) because nitrogen is the major nutrient limiting plant growth. Vitousek (1982) hypothesized that there are interrelationships between nitrogen content and litterfall production (Vitousek, 1984; Singh *et al.*, 2005). Plants from high nitrogen soil produced more litterfall than plants from infertile soil. Results of this study showed correlation between litter production by each dominant species and its nitrogen content (Figure 2). All of these dominant species drew similar patterns, in which high nitrogen increased litter production.

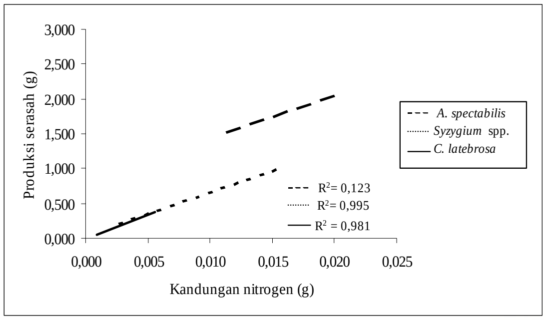

Figure 2. The relationship between litter production and nitrogen content of litterfall

NUE was negatively correlated with nitrogen content; high NUE in plants indicated poor soil conditions, while low NUE indicated more fertile soil. The highest NUE was recorded for *C. latebrosa* (849.7), followed by *A. spectabilis* (833.9), and *Syzygium* spp. (639.4). High NUE in *C. latebrosa* suggest that this species uses nutrients more efficiently than the other species. The relationship between NUE and nitrogen content of three dominant species can be shown in Figure 3.

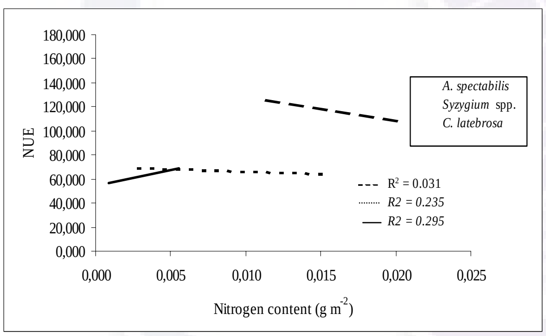

Figure 3. The relationship between NUE and nitrogen content

Litter Decomposition Rates

A. spectabilis exhibited the fastest litter decomposition rate (1.677 g m^{-2} yr^{-1}), followed by *Syzygium* spp. (1.612 g m^{-2} yr^{-1}) and *C. latebrosa* (1.503 g m^{-2} yr^{-1}). Litter decomposition rates are affected by litter quality and abiotic factors (Sariyildiz, 2003). The litter of *A. spectabilis* had low lignin concentration (28.1%), and was therefore easily decomposed. In contrast, *C. latebrosa* and *Syzygium* spp. litter contained high lignin concentration (51.0% and 50.8%, respectively) and decomposed slower than *A. spectabilis*. As a more complex structure, lignin is harder to decompose than cellulose. In addition, litter from *A. spectabilis* had the highest water content (83.2%) compared to *Syzygium* spp. (76.4%) and *C. latebrosa* (71.0%), thus producing more suitable conditions for decomposers, especially bacteria and fungi (Mason, 1976). Differences in decomposition rates determined the role of dominant species in supplying nutrients: fast litter decomposition provide high nutrient release, while slow decomposition implies nutrient retention in the ecosystem.

V. Conclusion

Results of this study showed that despite having the highest abundance, *C. latrebosa* gave a relatively small contribution to the available nutrient supply. However, this species showed the highest NUE index, thus indicating the ability to efficiently use nutrients. *A. spectabilis* contributed greatly to the availability of nutrients in the system, and showed high nutrient use efficiency. Results thus suggest that species with the highest abundance may not always contribute the most to nutrient cycling.

VI. References

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