Tropical Ecology **57**(3): 601-606, 2016 ISSN 0564-3295

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Litter production and decomposition dynamics of a rare and endemic bamboo species *Munrochloa ritcheyi* of Western Ghats, India

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Abstract: The present study examined the litter production, decomposition and nutrient release dynamics of *Munrochloa ritcheyi*, a rare and endemic bamboo species of Western Ghats. The litter production and decomposition were studied using the standard litter trap and bag techniques. The total annual litter production was 2.842 t ha^{-1} $year^{-1}$. Litter production followed a triphasic pattern with a major peak in February 2012 and two minor peaks in May and December, 2011. The rate of decomposition in *M. ritcheyi* was a good fit to exponential decay model suggested by Olson (1963). The decomposition rate constant of *M. ritcheyi* was 0.009 day^{-1} and the half-life was 77 days. The decrease in the N and K content of the decomposing litter was continuous whereas P, Ca and Mg showed temporary accumulation phases before final release. The release of nutrients from the decomposing litter was in the order N = Mg > K = Ca> P.

Key words: Bamboos, decomposition rate constant, litterfall, nutrient accumulation, nutrient release.

Handling Editor: Josef Gorres

Bamboos, the perennial woody grasses of family *Poaceae* with multifarious values and uses are reported to play pivotal role in biodiversity conservation and to contribute to soil and water management (Bystriakova *et al.* 2003). Southern Western Ghats of India are recognised for their bamboo diversity with a high degree of endemism because, out of the 22 naturally occurring bamboo species in this area, 17 are reported to be endemic. *Munrochloa ritcheyi* (Munro) M. Kumar & Remesh (*Bambusa ritcheyi*, *Oxytenanthera ritcheyi, Pseudotenanthera ritcheyi* (Munro) R. B. Majumdar) is a small solid clump forming bamboo reaching 5 m height; 25 - 35 mm diameter and an internodal length of 37 - 45 cm. It is one among the rare and endemic bamboo species of Western Ghats distributed naturally in Northern Kerala and Karnataka up to an altitude of 200 - 1100 m and it forms the part of moist deciduous forests and also seen in pure patches (Kumar 2011). With regard to utilization, it is one among the bamboo species closely linked with economy of rural people, for example, it has been exploited in the manufacture of umbrella handles, walking sticks, lathi, furniture and also as a support for betel plants in Northern Kerala (Kumar *et al.* 2009). Because of these uses, culms of *M. ritcheyi* are extracted by the local people in large quantities, which have led to depletion of the natural stock. The distribution of the species is highly scattered and the regeneration is slow hence, species has to be conserved with high priority (Kumar *et al.* 2009). In tropical ecosystems, litter dynamics play a very important role in the nutrition budgeting since the vegetation depends on the recycling of the nutrients contained in the plant debris. Such studies on litter dynamics are scanty especially in Western Ghats region. Therefore, the present

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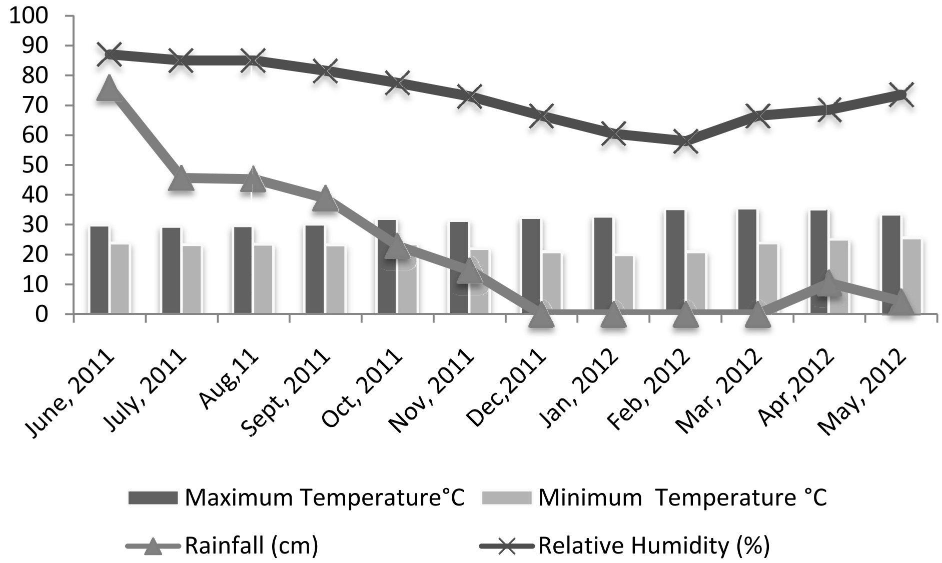

Fig. 1. Change in monthly rainfall (cm), relative humidity (%) and maximum and minimum temperatures (°C) during the course of study.

study focuses on the litter production and decomposition dynamics of this endemic bamboo species.

The study was initiated at Nellikutha Forest Station (11° 34' 57.6" N and 76° 15' 32.6" E) of Vazhikadavu Forest Range in Nilambur Forest Division, Kerala, India from June 2011 to May 2012. In Nilambur, *M. ritcheyi* occurs in well-drained hill slopes at an altitude of 250 - 850 m above means sea level. The total rainfall during the study period was 3338 mm, most of which was received during the Southwest monsoon season (June to September). The monthly rainfall, the average monthly temperature and humidity (averaged from daily records) during the course of study is given in Fig. 1.

As the distribution of *M. ritcheyi* was scattered we selected five sample plots of 25 m × 25 m each containing on an average 60 clumps (approximate spacing 3 m × 3 m). Litterfall of *M. ritcheyi* was captured using the specially designed litter traps made of bamboo baskets with diameter of 1 m and depth 10 cm placed in the five sample plots. The litter traps were fixed at the centre of sample plots, 25 cm above ground using wooden pegs. In order to study litter decomposition dynamics, freshly abscised leaves were collected during the February-March from the forest floor under the canopy. Samples of air dried litter weighing 20 g were placed in 15 × 15 cm nylon litter bags (2 mm mesh size) and 80 such bags were prepared. Litter bags were placed under the closed canopy of *M. ritcheyi* on first week of June 2011. Five samples were retrieved at monthly intervals until 95% decomposition of the litter was observed. The residual material from the monthly retrieved litter bags was separated carefully from the adhering soil particles using a small brush. Litter samples from each bag were oven dried at 70 ºC to constant weight. Mass loss over time was computed using the negative exponential decay model (Olson 1963). The time required for 50 % (t_{50}) and 99 % (t_{99}) decay was calculated as $t_{50} = 0.693/k$ and $t_{99} = 5/k$.

To determine initial litter chemistry as well as the chemistry of litter retrieved at each sampling period, litter samples were ground in a Wiley mill for chemical analysis. Total carbon was estimated using Euro vector (EA 3000) CHNS Elementar analyser and nitrogen and phosphorus using Continuous Flow Analyzer (Skalar San++). Potassium was estimated using a flame photometer (ELICO) and calcium and magnesium were estimated using an Atomic Absorption Spectrophotometer (VARIAN) (Jackson 1973). Nutrient content of the litter was calculated using the formula (Giashuddin *et al.* 1993).

$$\%\ \text{Nutrient remaining} = \left(\frac{\text{C}}{\text{C0}}\right) \times \left(\frac{\text{DM}}{\text{DM0}}\right) \times 100$$

where, C is the concentration of the element in litter at the time of sampling; C_0, the concentration of element in the initial litter kept for decomposition; DM, the mass of dry matter at the

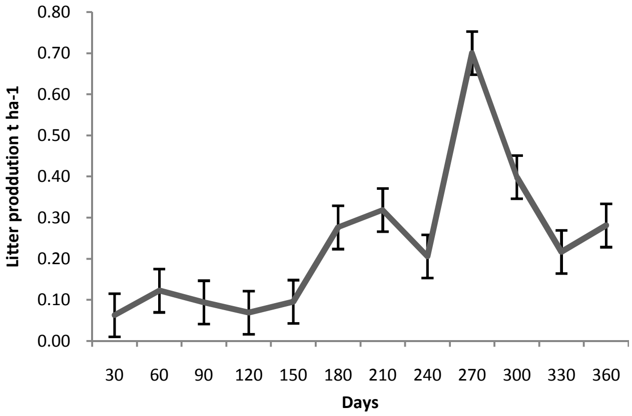

Fig. 2. Litter production of *Munrochloa ritcheyi* during June 2011 to May 2012.

time of sampling and DM_0, the mass of initial dry matter kept for decomposition. The data were subjected to One-way analysis of variance in SPSS 18 and treatment means were compared using least significant difference (LSD) wherever necessary.

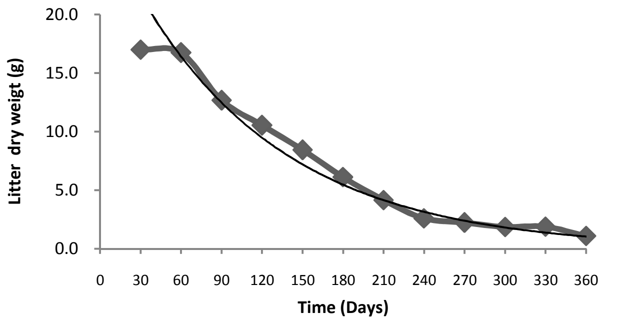

Fig. 3. Pattern of litter decomposition in *Munrochloa ritcheyi* (coloured line shows the actual weight loss and other the predicted mass loss).

The total litterfall of *M. ritcheyi* was 2.842 ± 0.411 t ha^{-1}, N = 60 spread throughout the year with significant (F_{59} = 11.11, P = 0.001) monthly variations (Fig. 2). Litter deposition followed a triphasic pattern with a major peak in February 2012 and two minor peaks in May and December 2011. The major peak of February might be associated with natural senescence of leaves induced by temperature and/or moisture stress in the region (Kumar & Deepu 1992). The measured litter production of *M. ritcheyi* was on the extreme low end of the spectrum for similar vegetation types and climates. For instance, the litter production in the moist topical forests is reported to be 2 to 11 t ha^{-1} (Proctor 1987). Perusal of literature indicated that the annual litter production of bamboos in the tropical and subtropical ecosystems varied considerably with species and locality. The average litter production of small clump forming *M. ritcheyi* was lower compared to large and medium clump forming plantation grown bamboos like *Bambusa bambos* (3.34 t ha^{-1}), *B. balcooa* (4.06 t ha^{-1}) and *Thyrsostachys oliveri* (4.49 t ha^{-1}) at the age of seven years from Palakkad district of Kerala, but it was higher compared to small clump forming *Ochlandra travancorica* (1.85 t ha^{-1}) (Jijeesh 2013). Similarly, litter production of *M. ritcheyi* was lower compared to natural stands of *Bambusa balcooa* and *B. pallida* (Upadhyaya *et al.* 2008) and *B. bambos* (Shanmughavel & Francis 1996) but was higher compared to *Dendrocalamus strictus* (Joshi *et al.* 1991) and *Arundinaria racemosa* (Upadhyaya *et al.* 2008).

During the decomposition, litter mass of *M. ritcheyi* decreased exponentially over time (Fig. 3). The regression model that depicted the progression of litter decomposition was $y = 28.43e^{-0.009t}$ (R^2 = 0.98) and which was a good fit to exponential decay model suggested by Olson (1963). The decomposition rate constant (*k*) was 0.009 day^{-1} and the t_{50} and t_{99} was 77 and 555 days respectively. Although, the decay rates were slower, monthly *k* values of *M. ritcheyi* (0.27) was slightly higher compared to *O. travancorica* (0.23) in Vazhachal of Thrissur district (Sujatha *et al.* 2003) and *O. setigera* (0.234) from Nilambur Forest Division (Thomas *et al.* 2014) situated in the Southern Western Ghats of India. The decay constants for tropical plantations are reported to range between 0.11 - 2.00 (O'connell & Sankaran 1997). The *k* value worked out at the end of the decomposition in the present study corroborate with this range. The initial chemistry of the litter mass of *M. ritcheyi* (Table 1) indicated that, among the nutrients carbon was the major constituent followed by nitrogen and the nutrient in least quantity was Mg. The ratios of carbon to N, P and K also varied and the C: N ratio was as low as 17.39. The C: N ratio of this species was lower compared to *B. balcooa*, *B. bambos* and *B. cacharensis* (Nath & Das 2011). But a higher C: P and C: K was observed. Initial N (Meentemeyer & Berg 1986) and lower C: N ratio (Swift *et al.* 1979) have been well correlated with the weight loss (Bargali *et al.* 2015). Seneviratne (2000) suggested that N contents lower than 2 % limit the decomposition of tropical litters. The lower decomposition rates of this species probably be explained by the lower C: N ratio and higher C: P ratio.

Table 1. Initial chemistry of the litter mass of *Munrochloa ritcheyi*.

Nutrient	Value
Nitrogen (%)	1.67
Phosphorous (%)	0.12
Potassium (%)	0.14
Calcium (%)	0.30
Magnesium (%)	0.11
Carbon (%)	29.07
C/N	17.39
C/P	250.12
C/K	203.96

The nutrient content of the litter mass was computed from residual nutrient concentrations and litter mass. The phosphorous and Ca content of the litter mass increased during the initial stages of decomposition and thereafter it decreased and a final release was observed (Fig. 4). The increase in nutrient content can be attributed to immobilisation of the elements by microbes and the final decrease due to mineralisation. There are contrasting reports on the P content in the litter during decomposition, in some cases; the concentration of P has been reported to decrease, while others report that P remains constant or a relative increase during decomposition. Moore *et al.* (2006) had attributed this to the leaf litter quality and the site, mainly whether P is limited. Attiwill (1968) reported that the loss of calcium from decomposing litter was slow due to its importance as a structural component. While, the decrease in the N and K content of the decomposing litter was continuous without any accumulation phase and the highest release occurred in initial months coinciding with the higher South-west monsoon rainfall. The decline in N content is associated with loss of easily leachable components of litter mass. Rodríguez *et al.* (2015) had reported that the litter contributes significant amount of N in agroecosystems like coffee plantations with low external N inputs. Attiwill (1968) found K was the most mobile element and this explains the rapid release of this nutrient. In contrast to N and P, K is not bound as a structural component in plants and is highly water soluble. Mg dynamics in decomposing litter with two phases; the initial leaching phase and the late immobilization phase similar to our study has been reported by many authors (Blair 1988; Laskowski & Berg 1993). Magnesium is not a structural material and exists mainly in solution in plant cells and thus leached out from litter in the initial phase of decomposition.

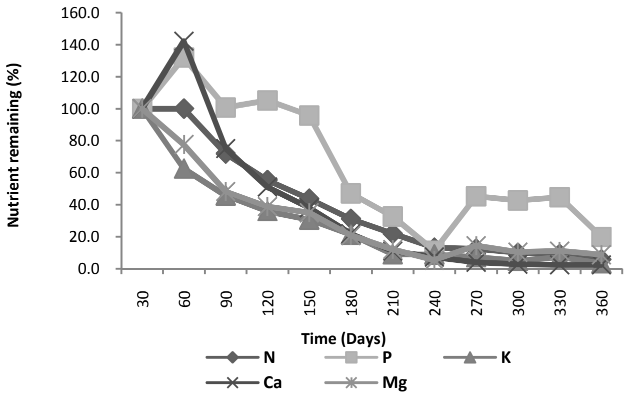

Fig. 4. The percentage nutrient remaining in the litter mass during decomposition of *Munrochloa ritcheyi*.

As nutrient release rates were all rapid in the in the early stages of decomposition and slowed down later, a negative exponential model was fitted. The relation between the time and release of nutrients was brought out using regression analysis. The exponential regression equation used to describe the nutrient release through time were significant at one percent level (P = 0.01). The equations obtained were

1. $y = 159.56e^{-0.0093x}$ ($R^2 = 0.99$)................. N
2. $y = 179.36e^{-0.0068x}$ ($R^2 = 0.72$)................. P
3. $y = 97.438e^{-0.0088x}$ ($R^2 = 0.94$)................. K
4. $y = 225.9e^{-0.0136x}$ ($R^2 = 0.98$)................. Ca
5. $y = 159.56e^{-0.0093x}$ ($R^2 = 0.99$)................. Mg

Table 2. The decomposition rate constant and time for decomposition of litter mass of *Munrochloa ritcheyi*.

Nutrient	Decay constant (k)	Time required for decomposition	
		50 % (t_{50})	99 % (t_{99})
N	0.0093	74.5	537.6
P	0.0068	101.9	735.3
K	0.0088	78.8	568.2
Ca	0.0088	78.8	568.2
Mg	0.0093	74.5	537.6

The decomposition rate constant, half-life and time for 99 % decomposition are given in Table 2. Phosphorous recorded lowest k value and consequently higher half-life. The highest k value was recorded for N and Mg and consequently a faster release. Hence the rate of nutrient release was N = Mg > K = Ca> P.

Acknowledgments

Authors acknowledge Dr. K.V. Sankaran, Former Director, Kerala Forest Research Institute for providing facilities and Kerala Forest Department for financial support.

References

Attiwill, P. M. 1968. The loss of elements from decomposing litter. *Ecology* **49**:142-145.

Blair, J. M. 1988. Nitrogen, sulphur and phosphorus dynamics in decomposing deciduous leaf litter in the Southern Appalachians. *Soil Biology and Biochemistry* **17**: 827-830.

Bargali S. S., K. Shula, L. Singh, L. Ghosh & M. L. Lakhera. 2015. Leaf litter decomposition and nutrient dynamics in four tree species of dry deciduous forest. *Tropical Ecology* **56**: 191-200.

Bystriakova, N., V. Kapos, I. Lysenko & C. Stapleton. 2003. Distribution and conservation status of forest bamboo biodiversity in the Asia-Pacific Region. *Biodiversity and Conservation* **12**:1833-1841.

Giashuddin, M. M., D. P. Garrity & M. L. Arago. 1993. Weight loss, nitrogen content changes, and nitrogen release during decomposition of legume tree leaves on and in the soil. pp 43-50. *In*: DO Evans (ed.) *Nitrogen Fixing Tree Research Report II,* Waimanalo, Hawaii.

Jackson, J. K. 1973. *Soil Chemical Analysis*. Printice hall, New York.

Jijeesh, C. M. 2013. *Litter Dynamics and Carbon Sequestration Potential of Selected Bamboo Species of Kerala.* Ph.D. Thesis. Forest Research Institute University, Dehra Dun, India.

Joshi, A. P., R. C. Sundrial & D. C. Baluni. 1991. Nutrient dynamics of Lower Siwalik bamboo forest in the Garhwal Himalaya. *Journal of Tropical Forest Science* **3**: 338-350.

Kumar, B. M. & J. K. Deepu. 1992. Litter production and decomposition dynamics in moist deciduous forests of the Western Ghats in Peninsular India, *Forest Ecology and Management* **50**: 181-201.

Kumar, M., C. N. Krishnankutty, P. V. Nair & R. C. Pandalai. 2009. *A Preliminary Study for the Conservation and Sustainable Utilization of Erankol and Koorankolly of the Western Ghats.* Kerala Forest Research Institute, Thrissur.

Kumar, M. S. 2011. *All India Coordinated Project on Taxonomy (aicoptax) Grasses & Bamboos (Part II) Bamboos of Peninsular India.* KFRI Research Report.

Laskowski, R. & B. Berg. 1993. Dynamics of some mineral nutrients and heavy metals in decomposing forest litter. *Scandinavian Journal of Forest Research* **8**: 446-456.

Meentemeyer, V. & B. Berg. 1986. Regional variation in mass-loss of *Pinus sylvestris* needle litter in Swedish pine forests as influenced by climate and litter quality. *Scandinavian Journal of Forest Research* **1**:167-180.

Moore, T. R, J. A. Trofymow, C. E. Prescott, J. Fyles &, B. D. Titus. 2006. Patterns of carbon, nitrogen and phosphorus dynamics in decomposing foliar litter in Canadian forests. *Ecosystems* **9**: 46-62.

Nath, A. J. & A. K. Das. 2011. Decomposition dynamics of three priority bamboo species of homegardens in Barak Valley, Northeast India. *Tropical Ecology* **52**: 325-330.

O'Connell, A. M. & K. V. Sankaran. 1997. Organic accretion, decomposition and mineralisation. pp 433-480. *In*: E. K. S. Nambiar & A. G. Borwn (eds.) *Management of Soil, Nutrients and Water in Tropical Plantation Forests.* ACIAR, Australia.

Olson, J. S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. *Ecology* **44**: 322-331.

Proctor, J. 1987. Nutrient cycling in primary and old secondary rain forests. *Applied Geography* **7**: 135-152.

Rodríguez, L. G., S. D. Ramírez., A. José, A. Amador & E. C. Schröder. 2015. Contribution of nitrogen from litter and soil mineralization to shade and sun coffee (*Coffea arabica* L.) agroecosystems. *Tropical Ecology* **56**: 155-167.

Seneviratne, G. 2000. Litter quality and nitrogen release in tropical agriculture: a synthesis. *Biology and Fertility of Soils* **31**: 60-64.

Shanmughavel, P. & K. Francis. 1996. Biomass and nutrient cycling in bamboo (*Bambusa bambos*) plantations of tropical areas. *Biology and Fertility of Soils* **23**: 431-434.

Sujatha, M. P., A. I. Jose & S. Sankar. 2003. Leaf litter decomposition and nutrient release in reed bamboo (*Ochlandra travancorica*). *Journal of Bamboo and Rattan* **2**: 65-78.

Swift. M. J., O. W. Heal & J. M. Anderson. 1979. *Decomposition in Terrestrial Ecosystems*. Blackwell Scientific Publications, Oxford.

Thomas, K., C. M. Jijeesh & K. K. Seethalakshmi. 2013**.** Litter production, decomposition and nutrient mineralisation dynamics of *Ochlandra setigera:* A rare bamboo species of Nilgiri Biosphere Reserve, India. *Journal of Forestry Research* **25**: 455-462.

Upadhyaya, K., A. Arunachalam, K. Arunachalam & A. K. Das. 2008. Above ground biomass and productivity appraisal of four important bamboo species growing along different altitudinal regimes in Arunachal Pradesh. *Journal of Bamboo and Rattan* **7**: 219-234.

(Received on 17.03.2014 and accepted after revisions, on 08.11.2014)