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RESEARCH ARTICLE

SEASONAL VARIATION IN LITTERFALL IN AN AGE SERIES *GMELINA ARBOREA* PLANTATION IN A NIGERIAN RAIN FOREST

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ABSTRACT

The study aimed at investigating the nutrient dynamics of Gmelina arborea stands aged 28, 29 and 30 years planted in a degraded soil in Shasha Forest Reserve, Osun State, Nigeria. Monthly variation in litter fall of Gmelina arborea stands aged 28, 29, and 30 years were studied for 13 months with litter traps in three 20m x 20m plots randomly selected in each stand. Monthly collections of litter fractions per stands were sorted into leaves, twigs, reproductive structures and others. Litters according to fractions per stand per month were oven dried at 80^0C for 48 hours. Samples were created for chemical analysis. Data collected were analysed using descriptive statistics and inferential at 0.05 level of significance. Litter fall (especially leaf fall) occurred throughout the period of collection (13 months), in the stands(S). The peak of total litter fall was recorded in October 2005 in S_1 (18.2%) while peaks were recorded in September in S_2 (11.21%) and S_3 (13.67%). The analysis of variance to determine interaction effect between fall of the litter fractions and age of the stands did not show any significant differences. Leaves constituted the bulk of litterfall across the three stands. The percentage of leaf litter to the total litter per hectare in stand ages 28, 29 and 30 years were 41.32, 34.19 and 24.48% respectively. While the contribution of unidentified litter thrash was highly insignificant. The study reveals that nutrient dynamics under Gmelina arborea plantations demonstrate a high restorative potential under a degraded soil in Shasha Forest Reserve.

Key words: Anthropometric characteristics, Length measurements, university cricket bowlers.

INTRODUCTION

The study of litter fall in any forest ecosystem is an essential step in the study of ecosystem productivity. Therefore the importance of litter fall and decomposition in a forest ecosystem cannot be over emphasized because they form the basis for nutrient availability and recycling between soil and the standing trees. The maintenance of satisfactory growth in a forest ecosystem is dependent on the recycling of essential elements through litter fall and litter decomposition. The quantity and composition of litter have been measured in a number of tropical regions and the results have been summarized (Bray and Gorham 1964, John 1973). They reported about 10,200 – 12,300kg/ha for tropical rainforest. Nye (1961) and John (1973) recorded about 10,540kg/ha and 9,660kg/ha for most semi-decidous forests of Ghana respectively. Also, litterfall in other African forests according to Landelout and Meyer (1954 cited by John 1973) varied from 8,260 – 13,370kg/ha in Cote-d'voire and 11,000 – 13,200kg/ha in Yangambi (Democratic Republic of Congo).

The amount and composition of litter within Nigerian forest ecosystem have also been estimated. Hopkins (1966) recorded about 7,170kg/ha for Omo-Forest Reserve and 4,720kg/ha for Olokemeji Forest Reserve. Onweluzo and Nwoboshi (1978) reported about 7,450 – 7765kg/ha for Sapoba forest. Ewel (1976) and Nwoboshi (1981a) noted that litter production increased with age and thinning intensity. The amount of litter fall in unthinned and thinned stands of *Tectona grandis* varied from 350kg/ha (7,631 stem/ha) to 5273kg/ha (2,224 stem/ha). It was reported that the amount of litter fall, nutrient content and season of fall did not reflect differences in stocking (Nwoboshi 1978). The pattern of litter fall varies with species and the climatic regimes in the area. Generally, litter falls throughout the year but the monthly mean rates of production of individual litter components and total litter do not necessarily correlate with monthly mean temperatures or monthly total rainfall (Lam and Dudgeon 1985). John (1973) however, showed that leaf-fall is mainly seasonal while woody litter production is more usually continuous and largely governed by physiological processes. Nwoboshi (1985b) found that litter falls throughout the year in teak plantation and Songwe et al (1988) found the same trend in the tropical rainforest. Also, Landelout and Meyer (cited by Ojo 2005) studying litter fall in Yangambi (Zaire) showed that there was low litter production during the rainy season, while Nye (1961) noted that litter fall in most tropical forest in Ghana was continuous and that during the short dry season, January to February, there was higher litter accumulation in February. Litter fall therefore constitutes one of the major path-ways in the bio-geochemical cycle of terrestrial ecosystems in the lowland tropics. It has been shown that a large proportion of the annual litter fall (especially leaf litter) decomposed within a year, usually between 2- 5 months (Nye, 1961; Madge, 1965; Hopkins 1966; John, 1973; Egunjobi, 1974) thus releasing minerals to be reabsorbed by the plants or to be lost to the ecosystem by leaching and runoff. Litter fall can then be described as the most wanted waste in a forest ecosystem. It is

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an indispensable component in the perpetuation of the physiological and bio-ecological processes in the forest. It is a major pathway in the energy and nutrient transfer in a forest ecosystem. It serves as a source of nutrients for various micro-organisms responsible for the release of mineral nutrients and thus, increases the water holding capacity of the soil [Loria, 1999]. Admittedly, litter fall and decomposition form the greater part of nutrient net production in the forest. The study was carried out to investigate seasonal variations associated with litter fall in *Gmelina arborea* plantation age series in Shasha Forest Reserve, Osun state, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in the *Gmelina arborea* plantations in Shasha Forest Reserve (SFR), Osun-State Nigeria. The forest reserve is located between Lats 7^0 and 7^0 3^0N and longs 4^0 and 5^0E. The total area of the forest reserve is currently 23,064ha out of which, about 1,523ha is under plantation of species such as *Gmelina arborea, Tectona grandis, Terminalia* spp, Pine and *Nuclea diderrichii.* The total annual rainfall ranges from 887mm to 2180mm. The mean annual temperature is 26.5^0C with the annual range between 19.5^0C and 32.5^0C. Soil types are generally deep to very deep, well drained and composed of loam, sandy loam, loamy sand and sandy clay-loam (Soils Survey Division, 1990). However, Bada (1977) and Kio (1978) described the geology and soils of the Forest Reserve as composed of undifferentiated crystalline rocks (basement complex). The 1976, 1977 and 1978 *Gmelina arborea* plantations are 40, 40 and 35 hectares respectively.

Methods of Data Collection

Selection and Demarcation of Plots

Reconnaissance survey of the study area was carried out in August and December 2004 and February 2005 for the purpose of establishing experimental plots. Nine (9) plots (three plots) per stand of 20 x 20-m (0.040) ha, were selected randomly from the 1976, 1977 and 1978 stands. The choice of three sample plots per stand is to ensure fair representation of the plantations, which is about 115 hectares in area. The sample plots were delimited with pegs and the boundary cleared. Three sampling units were randomly selected in each stand (i.e. nine plots in three stands with approximately 10m intervals between each plot). In each selected plot, five litter traps were randomly located. The litter traps were made of wooden frame (10cm) and plastic mesh base (1mm) to allow free passage of rain water. To avoid the decay of litter after being trapped, each litter trap was raised on four wooden legs 40cm above the ground. The litter in each 30cm deep trap was collected at fortnightly intervals starting for thirteen months .The litter was removed from the litter traps and spread out on large plastic sheets and later sorted into the followings; leaves, Twigs, foliage(R/S) and other (unidentified litter). The litter fractions were pre-dried in a well-ventilated room for one week before being enveloped and transported to the Department of Forest Resources Management Laboratory, University of Ibadan. The litter fractions per stand were bulked oven - dried at 80^0C for 48 hours to constant weight and weighed separately. After weighing, monthly bulk samples were then crated for each fraction in each stand.

Methods of data analysis

Data collected were analysed using a combination of Analysis of variance (ANOVA) , correlation analysis and multiple linear regressions. With the period of the year being the independent variable, the functional relationships of time to observed litter fall were carried out; where the value for time (month) based on the period of assessment. Total litter fall is therefore expressed as a function of time (t), t^2 the natural log of time $(Int)^2$ in various combinations of total litter fall, leaf litter, twigs, reproductive structures, time (t), time squared (t^2), natural log of time (Int) and natural log of time squared $(Int)^2$.

RESULTS AND DISCUSSIONS

Litter fall

The percentage monthly litter fall (Kgha^{-1}) for the three stands in the study site is presented on table 1 the result of analysis of variance (anova) of litter fractions (Kgha^{-1}) for the 3 stands is presented on table 2 while the mean annual litter fractions for the three is presented on table 3. Litter fall (especially leaf fall) occurred throughout the period of collection (13 months), in the stands(S). The peak of total litter fall was recorded in October 2005 in S_1 (18.2%) while peaks were recorded in September in S_2 (11.21%) and S_3 (13.67%) in 2006 (Table 1). The analysis of variance to determine interaction effect between fall of the litter fractions and age of the stands did not show any significant differences. Leaf litter had the highest contribution to the total litter fall in all the ages. While the contribution of unidentified litter thrash was highly insignificant. The analysis of variance for all the litter fractions followed the same trends. Similar trend was noticed in S_1 and S_2 in February 2006 (S_1 14.35%, S_2 20.25%) but marked decrease was recorded in S_3 at the same period (9.30%). This major peak were related to the dry period when there was little or no rain and the other peak may be as a result of sharp fall in rainfall .Tanner (1980) suggested that the production of more litter in dry season might be due to water stress.

Similar observations had been reported for Nigerian and other tropical forest (Egunjobi 1974; Nwoboshi 1981; *Songwe, et al*, 1988). The lowest litter was recorded in May 2005 in all the age series; 3.51%; S_2 2.60% and S_3 2.63%. The reason for this exceptionally low litter fall in this month was because of intruders on the experimental plots. There was a particular case of disturbance in all the plots across the stands in this month by Buffalo *(Syncerus caffer)*. This affected the quantity of litter fall recorded in all the stands. Some of the litter traps were destroyed by the animals which invaded the experimental plots. The animals were being hunted in the adjoining natural forest to the plantation. They escaped from their natural habitat and used the plantation as a buffer zone. However, comparison of the mean annual litter fall of this study (Table 2) with some studies in the tropical forest and plantation ecosystem showed that the mean annual litter fall recorded in this study was in accordance with those recorded in other studies. The differences between this study and some recorded in some tropical forests and plantation ecosystem may be as a result of species and site differences. Site differences according to (Vitousek, 1984) have been observed to affect the total and seasonal fall of litter. Heavy fall of reproductive structures was observed in February 2006 in all the stands, though there was a marked decrease in S_3. The leaf fall started in November 2005 and reached its peak in February 2006. The total contribution of reproductive parts to the total litter fall in February and March 2006 was particularly high in S_1 and S_2 compared to S_3. In S_1, the percentage contribution of reproductive structures was higher than the leaf fall, but low fall was recorded in S_3. The reason for this observation may be as a result of the age of the plantation. Other litter (thrash and unidentified litter) had a similar trend in all the stands. A close look at the different fractions showed that "other" had very little contribution to the total litter fall in all the ages. Light penetration in S_1 and S_2 was highly reduced. The main undergrowth under the plantation, were mostly wildings of *Gmelina arborea*. However, there were some species identified under the plantation. These include: *Chromolaena odorata, Elaeis guinensis, Carica papaya, Musa species, Blighia sapida, Mangifera indica,* and *Senna siamia.* These species are referred to as invaders which are scattered across the stands.

Pattern of litter fall

The seasonal pattern of litter fall for the period of investigation in the age series is shown in (Figures1 - 4). Litter fall was continuous throughout the year with the rate being particularly high in September and October 2005**,** and in February and March 2006 in all the stands. The values for litter fractions other than leaves were very variable and the mean monthly values were not significantly different across the stands .The highest mean monthly values were recorded during February and March in all the stands. During the first quarter of 2006, when high winds associated with the onset of the rainy season and with climatic change (no harmattan) in the study area in the month of December 2005. Figure 1 to 4 shows the seasonal patterns of fall of different litter fractions in all the stands. This observation was unusual. The total litter fall (kg/ha) (leaf and reproductive structures) was exceptionally high starting from January 2006 (Table 1). This trend was noticed in all the stands. The peak of the litter fall in 2005 occurred just after the short "dry spell" in August. This similar trend was observed in all the stands.

It also occurred in April 2005 and 2006 respectively. However, whatever reasons that may be responsible for the high litter fall in the peak period, environmental factors governing the onset of senescence and the development of abscission process cannot be over looked .Hopkins (1966) summarized the complexity of extrinsic and intrinsic factors which might have influence on leaf abscission under natural conditions and the relationship between them. Statistical analysis showed that, no significant differences at [P <0.05] was found in the pattern or the amount of litter in all the stands. The summary of mean total litter fall (kg/ha) of litter fractions in all the ages is shown in Table 3. In all the stands, there was a similar trend in total litter fall of different litter components. Twigs, reproductive structures, the unidentified components were negatively correlated as shown in table 4. However, all litter components were significantly correlated at [< 0 .05] on a monthly basis in all the stands.

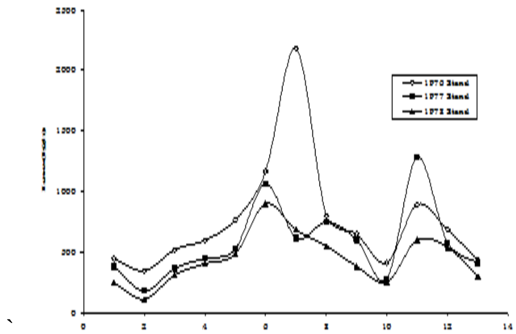

Figure 1: Monthly fall of leaves under three stands of *Gmelina arborea* in Shasha Forest Reserve

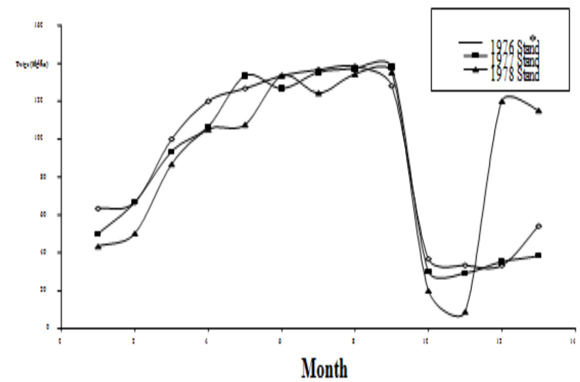

Fig. 2 Monthly fall of twigs in the three stands of Gmelina Arborea in Shasha Forest Reserve

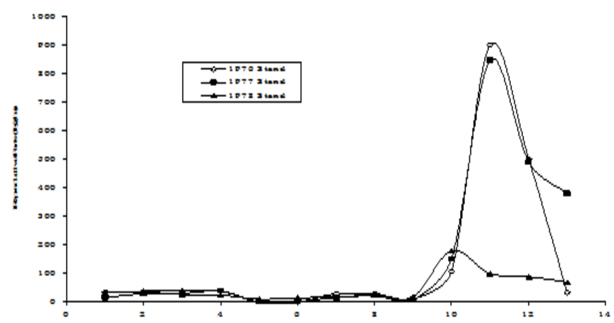

Figure 3: Monthly fall of Reproductive part under three stands of *Gmelina arborea* in Shasha Forest Reserve

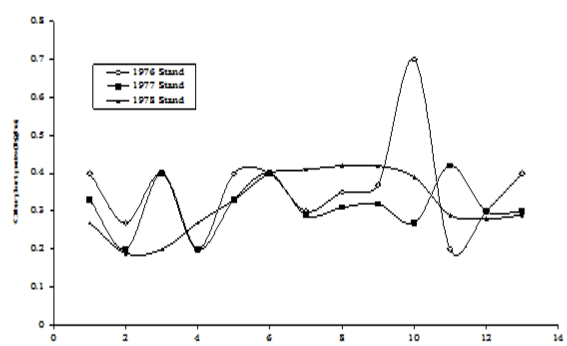

Figure 4: Monthly fall of others (unidentified plant) under three stands of *Gmelina arborea* in Shasha Forest Reserve

Table 1: Percentage monthly leaf fall ($kgha^{-1}$) in *Gmelina arborea* Plantation, Shasha Forest Reserve

Month/year	S_1 (%)	S_2 (%)	S_3 (%)
April, 2004	4.25	4.19	4.25
May	3.51	2.60	2.63
June	5.12	4.61	5.59
July	6.26	5.60	7.05
August	6.95	6.10	8.09
September	10.11	11.21	13.76
October	18.26	7.23	10.84
November	7.52	8.55	9.31
December	6.13	7.05	7.06
Jan. 2006	4.49	4.34	5.95
Feb	14.43	20.25	9.30
March	9.46	10.38	9.83
April	4.03	7.78	6.33
Total collection	100.6	99.89	99.99

Table 2: Analysis of variance (ANOVA) of litter fractions (oven dried- weig $Kgha^{-1}$ in 3- stands of *Gmelina arborea* Shasha Forest Reserve

Parameter	df	Ms	F	P- level
Leaves				
Stand (age)	2	340519.2	2.3745	0. 1103 (ns)
Error	30	143408.7		
Twigs				
Stand (age)	2	434.64	0.2225	0.801 (ns)
Error	30	1953.67		
Repr. Parts				
Stand (age)	2	15098.55	0.3377	0.7161 (ns).
Error	30	44705.15		
Other				
Stand (age)	2	2.9365	0.0611	0.9408 (ns).
Error	30	48.0398		

ns not significant

Table 3: Summary of mean annual litter fractions (kg/ha) in *Gmelina arborea* Plantation age series in Shasha Forest Reserve

Fractions	S_1 (1976)	S_2 (1977)	S_3 (1978)
Lv	798.86	590.85	449.05
Tw	98.44	95.14	86.28
Rs	110.75	105.84	44.27
Others	3.10	3.21	3.03
Mean total	1011.15	795.04	582.63

Note.
Lv = Leaves
Tw = Twig
Rs = Reproductive Structures
Other = unidentified litter
Source: Field Study April 2005 - April 2006.

Table 4: Correlation relationships of fall of different litter fractions with time

Variable	Month	LV	TW	RS	Others
Month	1.00	.35*	-.06	.47*	.66*
LV	.35	*1.00	.35*	.24	.01
TW	-.06	.35*	1.00	-.50*	-.72*
RS	.47*	.24	-.50*	1.00	.70
Others	.66*	.01	-.72*	.70*	1.00

Marked correlations were (significant at [<0 .05).

Prediction of litter fall

A number of multiple regressions were carried out using various litter fractions as dependent variables with different combinations of total litter fall, leaf litter, twigs, reproductive structures, others and time in month as independent variables as reported in table 5.

Thus, the regression equation derived for the three stands of *Gmelina arborea* plantation age series is as follows:

Log *LF = 2.660 + 0.026M*... 1
Where R^2= 0.20, $R^2_{adj.}$ = 0.18, SE = 0.202

The equation for stands two (i.e. the best regression fit) is given a follows:

Log LF_2 = 2.593 + 0.038M ------------------------------------ 2
Where R^2 =0 .42, $R^2_{adj.}$ 0.37, SE = 0.1798

In this regression analysis, stand two gives the best estimate in this study as shown in Table 6. The table show regression constant as well as coefficients of determination expressed as a percentage of R^2 for total litter fall, litter fractions and periods of assessment. The percentage R^2 values give a measure of the proportion of the variance of the dependent variables that is attributed to its linear regression on the independent variables. The pattern and rate of litter fall is largely determined by the species and the climatic regimes in that area. Lam and Dudgeon quoted by Ola-Adams and Egunjobi, (1992) noted that litter fall throughout the year but the monthly mean rates of production of individual litter components and total litter do not necessarily correlate with monthly mean temperatures or monthly rainfall. John (1973) noted that leaf fall is mainly seasonal while woody litter production is largely governed by physiological processes. However, Nwoboshi (1981b) found that litter fall throughout the year in teak plantations and Songwe et al (1988) in the tropical rain forest in Cameroon. Generally, wet season peaks in litter fall throughout the tropics, but *Acacia albida* is an example of tree that losses its leaves in the wet season and remain leaf throughout the dry season. Other researchers for example Edwards (1979) and Proctor et al (1983) have shown that maximum leaf fall during the wet season in various parts of the tropics. This has been attributed to the high species diversity that characterize these forests, indicating that litter fall may be spread out as a result of interspecific differences in leaf shedding time (Rogers and Westman quoted by Nwoboshi (2000).These differences make it difficult to generalize about patterns of litter fall within and between complex ecosystem.

Table 5: Regression Summary for Dependent Variables in the age series

Stat. Multiple Regress	Regression Summary for Dependent Variable: LOG TOTI R= .44694116, R^2=.19975640, Adjusted R^2=.17812820, F(1,37)=9.2359, p<.00434, Std. Error of estimate: .20188					
N=39	BETA	St. Err. Of BETA	B	SB	t(37)	p-level
Intercept			2.660376	.068576	38.78434	.000000
MONTH	.446941	.147065	.026257	.008640	3.03907	.004338

Table 6: Regression Summary for Dependent Variables in Stand 2

Stat. Multiple Regress	Regression Summary for Dependent Variable: LOG TOT2 R= .64878049, R^2=.42091612, Adjusted R^2=.36827213, F(1,11) = 7.9955, p<.01644, Std. Error of estimate: .17977					
N=13	BETA	St. Err. Of BETA	B	SB	t(37)	p-level
Intercept			2.592872	.105766	24.51527	.000000
MONTH	.648780	.229443	.037679	.013325	2.82764	.016442

Table 7: Summary of mean annual litter fall fractions (kg/ha) dry stand in an age series *Gmelina arborea* plantation in Shasha forest reserve.

Fractions	S_1 (1976)	S_2 (1977)	S_3 (1978)
Leaves	*798.86*	*590.85*	*449.05*
Twigs	*98.44*	*95.14*	*86.28*
RS	110.75	105.84	44.27
Other	3.10	3.21	3.03
Total	1011.15	795.04	582.63

Conclusion

This study therefore, supports the premise that rates of litter fall vary according to a number of factors including stand age. The mean total recorded in S_1 (older plantation) is higher than the mean total recorded in S_2 and S_3 (younger plantations) respectively.

REFERENCES

Bada, S. O. 1977; A comparative study of the growth of obeche *(Triplochiton scleroxylon,* K. schum) under plantation and natural forest conditions. M. Phil Thesis,University of Ibadan. 136

Bray,J. R. and Gorham, E. 1964: Litter production on the forest of the world. Adv. Ecol. Research 2:101-157.

Edwards, P. J. 1977: Studies of mineral cycling in a montane rain forest in New Guinea II. The production and disappearance of litter . J. Ecol., 65: 971 – 992.

Egunjobi, J. K. 1974: Litterfall and mineralization in a Teak *(Tectona grandis L inn. F.)* stand. Oikos 25: 222 – 226.

Egunjobi, J. K. and Bada, S. O. 1979: Biomass and nutrient distribution in stands of *Pinu caribael L.* in the dry forest zone of Nigeria. Biotropical 11 (2) : 130 – 135.

Hopkins, B. 1966: Vegetation of the Olokemeji Forest Reserve Nigeria. iv. The litter and soil with special reference to their seasonal changes. *J. Ecol.* 54: 687 – 703.

John, D. M. 1973: Accumulation and decay of litter and net production of forest in tropical West Africa. Oikos 24: 430 – 435 pp.

Kio, P. R. O. 1978: Stand development in naturally regenerated forest in South-Western Nigeria. Ph.D Thesis, University of Ibadan, 594 pp.

Loria, S. A. 1999; Litter fall: The most wanted waste. The Ecosystems Research and Development Bureay, Dept. of Environmental and Natural Resources vol. 25, No 3. J. Canopy international, philikppiners pp. 12.

Madge, D. S. 1965: Leaf fall and litter disappearance in a tropical forest Pedobiologia 5:273 – 288.

Meyer, B. S., Anderson, D. B., Bohning, R. T. and Frantianne D. G. 1973: Introduction to plant physiology. D. van Nostrand Company, New York p 591.

Nwoboshi, L. C. and Onweluzo, S. S. 1978: Organic matter and nutrient status of some rainforest soils in southern Nigeria. Biotropica.

Nwoboshi, L. C. 1981a: Nutrient cycling in a managed teak plantation ecosystem. 1 Litterfall and macro-nutrient return to the forest floor. *Nig. Journ. Agric. Sci.* 3(1): 9 – 14.

Nwoboshi, L. C. 1985: Biomass and nutrient uptake and distribution in *Gmelina arborea* pulpwood plantation age series in Nigeria: Journal of *Tropical for Resources* 1 (1): 53 – 62.

Nwoboshi, L. C. 2000: The nutrient factor in sustainable forestry. Ibadan University press. Pp

Nye, P. H. 1961: Organic matter and nutrient cycles under moist tropical forest plant and soil 13: 33 – 346.

Ojo, M. O 2005: Organic matter and nutrient dynamics of the natural rainforest and teak plantation in Akure Forest Reserve, Nigeria. Unpublished PhD thesis, Federal University of Technology, Akure.

Ola-Adams, B. A. 1978: Litterfall and disappearance in a tropical moist semi-deciduous forest, *Nig. J. Forestry* 8 and 2, 21 – 26.

Ovington, J. D. 1962: Quantitative ecology, and wood ecosystem concept. Adv. In ecological research, 1:103 – 192.

Proctor, J., Anderson J. M., Fodgen S. C. L. and Vallack H. W. 1983: Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak. 11. Litterfall, litter standing crop and preliminary observations on herbivory. J. Ecol. 71: 261-283.

Songwe, N. C. 1984: Litter production and decomposition in a tropical rainforest, southern Bankundu Forest Reserve, Cameroon, Ph.D. Thesis University of Ibadan. Nigeria.

Songwe, N. C., Fasheun, F. E. and Okali, D.U.U. 1988 Litterfall and productivity in a tropical rain forest, Southern Bakundu Forest, Cameroon. J. Trop. Ecol. 4:25-37. Vitousek, P. M. 1984: Nutrient cycling and nutrient use efficiency. American Naturalist 199: 553 – 572.

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