Importance of Decomposition Processes for the Functional Classification of Tropical Forest Ecosystems Proposed in Sierra del Rosario, Cuba

M. E. RODRIGUEZ, R. A. HERRERA and E. GONZALEZ

Institute of Ecology and Systematics, Department of Soil Ecology, Havana /CUBA/

In tropical ecosystems the litter decomposition rate is rather high, but this does not necessarily exclude the accumulation of an A_0 horizon with more or less developed L, F and H layers. The standing crop of organic matter depends on the input of plant litter and the output of its own decomposition. At the same time the characteristics of the material to be decomposed /litter/ reflect the climatic, edaphic, water or nutrient stress under which the ecosystem has been developed and the stage of vegetation it has reached. The relation between litter accumulation and root mat formation was pointed out by HERRERA et al. /1978/ in Venezuelan Amazonian forests and HERRERA et al. /1987/ in Cuban forests. The latter authors stressed the role of sclerophyllous plants in determining this accumulation and also the high correlation between the sclerophyll of the leaves and that of the rootlets in different Cuban forests. HERRERA and RODRIGUEZ /1988/ proposed the term sclerorrhyzy to qualify the hardness and scleromorphic condition of the rootlets mainly in the upper part of the soil profile and specially in relation to the root mats. MEDINA /1973/ found that the sclerophyllous nature of plant leaves may develop not only as a water stress response but also due to oligotrophic conditions, which are predominant in many tropical soils, particularly in lateritic ones.

This paper presents data for the functional characterization of 14 Cuban forest ecosystems.

Materials and methods

The functional classification of tropical forests proposed by HERRERA et al. /1988/ and presented in Table 1 was used for the characterization of the forests studied. The relation between the weights of the L and F + H layers was considered to reflect the litter decomposition rate of the ecosystem. Methods for determining this coefficient, as well as the sclerophyllous character of the vegetation, are described by the same authors.

Table 1

Main and subordinate categories proposed for the functional classification of tropical forests

Categories: Main	Subordinate	Abreviation /variants/
1. Type of vegetation	Evergreen forest	SV
	Semideciduous forest	SD
2. Forest tolerance to water or nutrient stress	Oligotonic	O
	Eutonic	E
3. Forest structure in relation to topography or situation	Continental	C
	Insular	I
4. Mean leaf area corresponding to the species producing 75% or more of litter fall	Mesophyllous /mean greater than 45 cm^2/leaf/	ms
	Microphyllous /mean less than 45 cm^2/leaf/	mi
5. Vegetation height DOM = dominant storey height EME = emergent height	high: DOM /20-30 m/ EME /35-40 m/	A
	middle: DOM /10-20 m/ EME / -30 m/	M
	low: DOM / 3-15 m/ EME / -20 m/	B
6. Presence, type and size of the root mat in the forest floor	Root mat absent	
	Root mat in leaf matrix	ER_{L*}
	Root mat in humus matrix	ER_{f*}
	Superficial root layer, without leaves or humus	ER_{O*}
	/* height /cm/ of the root mat/	
7. Mean values of sclerophyll /dry weight: fresh weight/ of the species producing 75% or more of the litter fall	hyposclerophyllous /less than 0.319/	hf
	mesosclerophyllous /0.320-0.409/	mf
	sclerophyllous /greater than 0.410/	ef
8. Mean values of sclerorrhyzy /dry weight: fresh weight/ of the forest rootlets	hyposclerorrhyzous /less than 0.319/	hr
	mesosclerorrhyzous /0.320-0.409/	mr
	sclerorrhyzous /greater than 0.410/	er
9. Fermentation rate /zymosis/ of the forest floor necromass. /Relation between L and F+H layers: $\frac{L}{F+H}$/	taquizymotic / > 10.0/	tz
	mesozymotic /5.0-9.9/	mz
	eremazymotic /1.0-4.9/	ez
	eueremazymotic / <1.0/	eez
10. Seasonal litter production /percentage of the annual production during the drier 6 months/	Not seasonal / < 60%/	S
	seasonal / > 60%/	S_*
	/* percentage of litter production/	

Results and discussion

Some of the climatic and soil characteristics of the localities and sites studied are listed in Table 2. The range of soil trophic conditions is shown with P, N or PKN as limiting factors. Water stress caused by edaphic or climatic dryness is also pointed out in the case of Moa Ferritic soils and El Retiro Rendzina soils. Data on the functional classification

Table 2

Some climatic and soil characteristics of the forests studied
Classification according to the Institute of Soils, CAS, 1975

Locality /site	Soil type	pH H_2O	pH KCl	Limiting factor	Trophic type	Slope /dg/	ppt mm/y	mean T °C
1. Sierra del Rosario		/400 - 500/					2013	24.4
1.1/ Vallecito	Fersialitic Yellow Brown	6.6	6.1	P /st.*/	Mesotr.	20–30		
1.2/ Las Peladas	Fersialitic Yellow Red	6.4	5.8	N P	Oligotr.	20–30		
1.3/ Majagual	Fers. Y. B.	6.5	6.1	P /?/	Mesotr.	15–25		
1.4/ Terrazas	Fers.Y.B. /Ap/altered by terracing	7.6	7.4	P /st.*/	Mesotr.			
2. Gran Piedra	/700-800/						1500	22.0
2.1/ Isabelica "1" "2"	Ferralitic Red.lixiv. typical	6.5	6.2	P /?/	Oligotr.- Mesotr.	30-45		
2.2/ Canada /gully/	idem	6.5	6.2	P N/?/	idem	10–30		
3. MOA	/300-400/						2262	22.6
3.1/ pinar + latifolias	Ferritic Purple	6.2	5.6	P K N edaphic dryness	Oligotr. /Fe/	10–20		
3.2/ pinar /P.cubensis/	idem	5.2	4.3	idem	idem	idem		
4a. Mayari	/200-300/						1600	26.2
4a.1/ Ocujal Nat.forest /gully/	Ferritic Purple	7.2	6.7	P K N	Oligotr. /Fe/	20–30		
4a.2/ Casuarina plantation	Remnants of mining	7.2	6.3	P K N	Very Oligotr.			
4b. Pinares de Mayari		/600 - 700/					1589	21.8
4b.1/ Pine plantation P.cubensis 25 years	Ferritic Purple typical			P K N	Oligotr.	0–5		
5. Yaguaramas	/20-30/						1200	25.5
5.1/ bosquecito	Ferralitic Yell.Red. lixiviated	5.7	5.2	P N edaphic dryness	Oligotr.	0		
6. Baconao, Santiago de Cuba,	/20/						687	26.8
6.1/ El Retiro	Rendzina Red	8.1	7.4	water	Eutroph.	10–15		

/1/ altitude m.a.s.l. /st.*/ seasonal shortage of the studied forests in relation to the decomposition process are shown in Table 3.

The relationships between sclerophyll /ef/ and sclerorrhyzy /er/ and the L:F+H ratio, and between these ratios and root mat formation were analysed. A general negative correlation was found /ef/L:F+H : r=-0.61, p=0.05, n=12/ $ER_{/cm/}$ /L:F+H : r=-0.82, p=0.01 n=11/, confirming the results obtained by HERRERA et al. /1987/. As for the decomposition constant /K/ obtained in previous studies by the authors, negative correlations were obtained between this parameter and both root mat formation /1/ and the sclerophyllous character of the ecosystem /2/ /r=-0.55, p=n.s., n=10/ /r=0.85, p=0.01 n=9/.

The results show that two general functioning systems are present in tropical forests, as observed by RODRIGUEZ and ULEHLOVA /1986/, HERRERA et al. /1987/:and RODRIGUEZ /1988/:

1. That found in oligotrophic ecosystems /O/ not so stressed by environmental conditions, in which low sclerophyllous values /ps/pf of leaves and rootlets < 0.409/ are associated with high litter decomposition rates /L:F+H or K/. Thus, poor litter accumulation, the absence of root mats and rapid nutrient cycling with high biomass conversion are the main functional characters of these forests. This is demonstrated by cases 1.3, 1.4 and 2.2 in Table 3.

2. That found in eutrophic ecosystems /E/ which are water or nutrient stressed and/or influenced by other primary stressing factors, such as topography, soil mother rocks or situation, as in the case of forests 1.1, 2.1, 2.3, 3.1, 4a.1, 4a.2 and 5.1 in Table 3. In these cases high sclerophyllous values in leaves and rootlets are related to low decomposition rates: L:F+H < 0.5 and K < 2.0 /approx./. Thus, litter accumulation with the development of L, F and H or FH layers, allows root mat formation with VA or ECTO + VA mycorrhyzal symbiosis. In these forests an efficient absorption and conservation of the nutrients released during litter decomposition is achieved, and slow nutrient cycling, closely bound to the organic components of the ecosystem, allows the development of effective ways to resist environmental stressing factors.

Four exceptions to these two general patterns must be explained:

1.2 - Las Peladas, Sierra del Rosario. Classification E - ef - er - ER /thin and superficial/ with relatively low K; there is a high L:F+H ratio, between the tz range limits. In this case there is no H layer and the humification products seem to be lixiviated /high free Fe in profile and probable formation of fulvic acid/.

3.2 and 4b.1 - Pine /P. cubensis/ forests in Moa and Pinares de Mayari. The sclerophyllous and sclerorrhyzic character would allow root mat formation, but this is not present /ER/. Again the H layer is lacking. This is typical of moder humus in pine forests. According to ORTEGA /1985/, in soils developed on serpentinite very poor in Ca and Mg, the humification of pine litter is very difficult because of the high humine content in the upper soil layer and the high C/N ratio. It is interesting to point out that when latifoliar plants are present in the same ecosystem, as in the case of 3.1 and 4a.1, root mats are well developed /see Table 3/. The same has been observed by the authors when coffee plantations are introduced under pine shadow. A root mat even appears in the FH layer.

6.1 - El Retiro. Dry xerophyllous ecosystem /very high values of ef and possibly er/. Litter accumulation and root mat formation are not possible because of the stressing influence of physical environmental factors /dryness and high temperature/, leading to rapid litter flushing and very high K values. In the light of the previous and present results it seems that sclerophyll is a necessary condition for litter accumulation, as scleror-

Table 3

Functional characteristics of the forests studied in 6 Cuban localities.

Locality /site	Forest type	exposi-tion	L	F+H	L:F+H	sclero- phyly	sclero- rrhyzy	Root-mat /cm/	zimo sis /1/	K/D_{50} /mth./
1. Sierra del Rosario	Pluvisilva sub-mountainous									
1.1/ Vallecito	SV-E-I-ms-M	N-NE	235	600	0.392	0.421 ef	0.430 er	ER f1-3	ez/FH/	1.96 //4.2/
1.2/ Las Peladas	SV-E-C-mi-B	N-NE	704	240	2.930	0.462 ef	0.439 er	ER 11-2	tz-mz /L/	0.96 //8.7/
1.3/ Majagual	SV-O-I/C/-mi-B	W	288	152	1.895	0.268 hf	0.306 hr		tz	3.19 //2.6/
1.4/ Terrazas	SV-O-I/?/-ms-B	NW	96	76	1.270	0.268 hf	0.306 hr		tz	3.17 //2.6/
2. Gran Piedra	Pluvisilva montaneous									
2.1/ Isabelica	/*/									
"1"	SV-E-I-ms-M	S-SE	311	805	0.387	0.36 ef	0.408 er	ER f1-3	ez/FH/	
"2"	SV-O-C-ms-M	NW	466	166	2.801	0.294 hf	0.26 hr		tz/L/	
2.2/ Canada /gully/	SV-E-I/?/-ms-M	N	106	898	0.118	0.39 ef	0.401 er	ER f3-5	ez/FH/	** 1.54 //5.4/
3. MOA	Pine forest on laterite									
3.1/ Pines +latifollas	SV-E-I-mi-B	SW	1812	2163	0.837	0.71 rf	0.81 er	ER f3-5	ez/FH/	0.48 //16.8/
3.2/ Pines P.cubensis	SV-E-I-mi-M	SW	1349	4678	0.288	0.71 ef	0.81 er		ez/F/	0.38 //21.8/
4a. Mayari	Pine forest on laterite									
4a.1/Ocujal Nat.forest /gully/	SV-E-I/?/-ms-M	ENE	1248	5349	0.234	0.75 ef	0.8 er	ER f3-5	ez/FH/	
4a.2/Casuarina plantation	SV-E-I/?/-mi-B	SW	935	4285	0.218	0.83 ef	0.9 er	ER f2-4	ez	0.57 //14.6/
4b. Pinares de Mayari	Pine forest on laterite									
4b.1/Pine plantation P.cubensis/25 years/	SV-E-I-mi-M	total	453	1103	0.411	0.71 ef	0.81 er		ez/F/	
5. Yaguaramas	Savanna semi-deciduous forest									
5.1/bosquecito	SD-E-I-mi-B	total	1220	4425	0.276	0.77 ef	0.65 er	ER f3-4	ez/FH/	1.18** //7.0/
6. Baconao Stgo.Cuba	Sub-perennifoliar dry forest									
6.1/El Retiro	sd-E-I-mi-B	S	219	113	1.94	0.9 ef	? er		tz	7.11** *** //1.2/

/1/ accumulation layer

/*/ data from O.Pelicie, C. Vinent and J. Reyes - /personal communication/

/**/ seasonal fluctuation

/***/ arid climate, physical factors very stressing

L and F+H in g/m^2; K = decomposition constant /according to OLSON, 1963/; D_{50} mean decomposition time /months/. Other symbols according to Table 1

rhyzy is for root mat formation in eutonic /water or nutrient stressed/ ecosystems with slow or very slow decomposition rates /ez or eez, as measured by L:F+H or K/. However, when edaphic factors or physical components of the environment prevail, some of these characters are not expressed and the ecosystem develops differently to avoid stress factors.

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