

Litterfall and Litter Decomposition in Chestnut High Forest Stands in Northern Portugal

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Introduction

Sweet chestnut (*Castanea sativa* Mill.) is an important species in the North of Portugal for fruit as well as for timber. Today, the role of the chestnut areas is not only limited to production of fruit and timber but also other aspects such as landscape, environmental and ecological protection which are very important. Consequently, its sustainable management is essential to maintain the health and vitality of the chestnut areas, therefore increasing the economical and social benefits of the local population. The site sustainability depends on the knowledge of the inputs and outputs of the system. Litter is an important reservoir of nutrients in maintaining the site's productivity and sustainability. In poor nutrient soils, the ecosystem's productivity is highly influenced by the efficiency of nutrient cycling. However, growth and productivity of forest ecosystems depend mainly on the amount, nature and decomposition rate of litter. Litterfall and its accumulation, litter weight loss due to decomposition and nutrient pools are important to better understand the recycling of elements associated with the turnover of organic matter. The leaves are the main vector of the potential return of all nutrients to the holorganic horizon in chestnut stands (Santa Regina, 2000). The aim of this research is to study the litterfall, the litter decomposition process and the rate of litter decay in these ecosystems to improve the sustainable management of chestnut areas.



General characteristics of the studied chestnut stands.

Materials and Methods

Data collection

The study was conducted in the three high forest mature chestnut stands located in Northern Portugal. Aboveground foliage litterfall was measured using seven circular 1m² littertraps that were randomly placed inside and outside of the sample tree plots (area 1000 m²) in each stand. Littertraps were deployed in September 2008 and litter was collected monthly from the fall-winter of 2008 until the fall-winter of 2009. The litter was separated into leaves, branches, fruits and burs. All litter fractions were dried to constant weight at 70° C.

Decomposition of leaf litter and burs of Chestnut was studied during 1.5 years through weight loss and nutrient concentration evolution, using the nylon mesh bag technique (Bocock, 1960). The 75 nylon leaf-bags and 30 bur-bags (1 mm mesh) were placed on the forest soil, in 5 randomly distributed groups, on the experimental chestnut plot in each stand.

Data analysis

An ANOVA was performed to compare the total amounts of litterfall among the three study sites. A Tukey test ($\alpha = 0.05$) was done for mean multiple comparisons. The same statistical analysis was used to compare the biomass mineral concentrations. The annual decomposition constant k (Olson, 1963) was calculated using $\ln(X_0/X_t) = kt$, the Half-life ($t_{0.5}$) [$t_{0.5} = 0.693/K$] and the turnover [$1/k$] was calculated for the leaves and burs in the three situations.

Chestnut stands	Marão	Padrela	Bornes
Age in 2009	71	64	53
Altitude (m)	900	850	800
Slope (°)	5-10	25-30	15-20
Density (tree ha ⁻¹)	360	470	1260
Mean DBH (cm)	40.5	34.0	26.8
Mean height (m)	29.9	21.3	23.8
Mean annual temperature (°C)	13.4	12.5	11.9
Mean annual precipitation (mm)	2505	1132	1009
Main soil type	Umbric Regosols	Dystric Regosols	Dystric Cambisols

Results

Average annual litter production and bio-element amounts of litterfall components in three high forest mature chestnut stands.

Stands	Litter fraction	Litter production Mg ha ⁻¹ yr ⁻¹	kg ha ⁻¹ yr ⁻¹							
			N	P	K	Ca	Mg	S	C	
Marão	Leaves	3.33	79.43	49.72	3.42	5.81	14.61	8.38	1.50	1819.31
	Branches	0.27	6.38	1.63	0.13	0.30	3.08	0.71	0.07	142.65
	Burs	0.33	7.79	2.93	0.26	0.64	0.64	0.63	0.05	171.97
	Fruits	0.27	6.41	3.06	0.29	1.14	1.25	0.99	0.11	143.36
	Total	4.19a	100.0	57.34a	4.10b	7.89b	19.57b	10.70b	1.72b	2277.29a
Padrela	Leaves	3.21	69.78	46.37	3.73	14.87	22.41	10.61	2.77	1575.70
	Branches	0.18	3.99	1.54	0.09	0.48	1.43	0.31	0.06	92.78
	Burs	0.64	13.85	8.46	0.76	3.60	3.69	1.30	0.36	311.85
	Fruits	0.57	12.38	7.43	0.58	2.90	1.95	1.23	0.29	281.90
	Total	4.60a	100.0	63.79a	5.16a	21.86a	29.48a	13.44b	3.48a	2262.21a
Bornes	Leaves	3.09	78.04	31.6	3.41	14.79	28.01	16.03	1.22	1653.86
	Branches	0.19	4.74	1.03	0.07	0.20	1.47	0.34	0.02	95.72
	Burs	0.33	8.28	2.31	0.22	1.03	1.62	1.24	0.07	167.31
	Fruits	0.35	8.94	3.79	0.38	2.15	0.49	0.70	0.11	176.07
	Total	3.96a	100.0	38.72b	4.09b	18.16a	31.60a	18.31a	1.43b	2092.97a

Letters indicate significant differences at p<0.05 among means (Tukey test) for total.

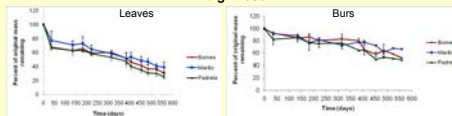
As in the case of most forest ecosystems, the leaves comprised the most important fraction of litter biomass ranging from 3.1 to 3.3 Mg ha⁻¹ year⁻¹ representing 69.8–79.4 % of the total litterfall. They also sequester the largest amount of carbon.

These results are consistent with Santa Regina (2000) for the leaves component but not for the others because, in our case, the contribution of burs and fruits is greater than branches. However, the densities and ages of the stands are very different. The values of total litterfall are approximate to the values of 3.9 Mg ha⁻¹ year⁻¹ reported by Pires *et al.* (1994) for chestnut groves and 4.9 Mg ha⁻¹ year⁻¹ referred to by Regina (2000).

Initial chemical composition (g kg⁻¹) of leaves and burs litter of chestnut stands

Site	(g kg ⁻¹)							
	C	Ash	N	P	K	Ca	Mg	C/N
Leaves								
Bornes	541.30	49.00	5.65	1.29	3.11	6.56	3.42	95.81
Marão	597.70	54.00	12.73	0.79	2.90	4.95	2.45	46.97
Padrela	525.93	43.00	7.83	0.79	4.60	4.51	2.43	67.19
Burs								
Bornes	459.27	30.60	6.10	0.74	4.90	3.43	1.64	75.25
Marão	538.75	22.30	11.17	0.86	4.03	2.89	1.19	48.24
Padrela	473.10	22.60	0.91	0.70	6.30	2.89	1.53	51.79

Weight loss



Proportion of dry-mass remaining as a function of incubation period in decomposing leaf and bur litter

The three stands show the same tendency in the proportion of the initial dry weight released from the litter, for leaves as well as burs, after 1.5 years.



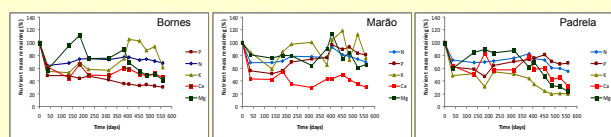
Placing nylon mesh bags on the forest soil

Decomposition rate (K), half-life time (t_{0.5}) and turnover, for leaves and burs of chestnut incubated during a 1.5 year study in three stands in northern Portugal.

Site	Leaves		Burs	
	K (years ⁻¹)	Half-life (years)	Turnover (years)	Turnover (years)
Bornes	0.60	1.15	1.66	0.37
Marão	0.52	1.33	1.92	0.25
Padrela	0.74	0.93	1.35	0.43

The litter decomposition and nutrient released were greater in Padrela followed by Bornes and Marão, respectively.

Temporal changes in nutrient mass remaining



K and Mg mass dynamics varied considerably from Padrela to the other two sites. There was temporary immobilization of K and Mg in Bornes and Marão along the study period.

In general, an initial period of strong mineralization was detected for all analysed minerals. This phase was followed by a period of stabilization or progressive little release, safeguarding the exceptions of K and Mg.

Conclusions

- At the end of the study period (1.5 years), average mass loss was 69% for leaves and 45% for burs. The mass loss was greater in Padrela followed by Bornes and Marão, respectively.
- On average, depending on the environmental conditions, for the mature high-forest chestnut: The decomposition rate is 0.62 year⁻¹ for leaves and 0.35 year⁻¹ for burs.
- The half-life is 1.13 years for leaves and 2.08 years for burs.

References

Bocock, K.L., Gilbert, O.J., Capstick, C.K., Turner, D.C., Ward, J.S., Woodman, M.J. 1960. Changes in leaf litter when placed on the surface of soil with contrasting humus types. *Journal of Soil Science*, 11: 1-8.
 Olson, J.S. 1963. Energy storage and the balance of producers and decomposers in ecological systems. *Ecology* 44: 322-331.
 Pires, A.L., Pereira, E. and Martins, A.A. 1994. Nutrient cycling in chestnut groves in the Trás-os-Montes region. In: Romano, Ed., *Biological Criteria for sustainable development in Natural Degenerate Forests of Mediterranean Europe*. Montpellier, pp. 9-22.
 Santa Regina, I. 2000. Organic matter distribution and nutrient fluxes within a sweet chestnut (*Castanea sativa* Mill.) stand of the Sierra de Gata, Spain. *Ann. For. Sci.* 57:691-700.

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