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Rhythm and estimation of litter fall in a Mediterranean forest ecosystem

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Abstract - Under Mediterranean climate, north-western Tunisia, vegetation is characterized by the presence of many sclerophyllous species of which the most abundant and most representative are the Cork Oak and the Zeen Oak. The latter, considered as marscente species, loses part of its leaves in winter, whereas in cork oak, which is an evergreen species, litter falls therefore occur throughout the year with nevertheless an optimum in the spring. Moreover, litter falls are not always equal from one year to the next. The aims of the present work are therefore, to determinate the rhythm of litter fall (focusing on cork oak) and, jointly, to evaluate annual leaf production by the trees. The study was carried out in the the Bellif forest located in the Northwest of Tunisia. Where, despite a high monthly variability, litter falls are characterized by a regular rhythm.

Keywords: Mediterranean ecosystem, *Quercus suber*, *Quercus canariensis*, litter fall, collectors, Seasonal rhythm.

1. Introduction

Litter fall is a key process in forest nutrient cycling and it is the main above-ground contributor of carbon and nutrients to the forest floor. It is an important reservoir of nutrients from forest ecosystems on poor soils, where vegetation relies heavily on nutrient recycling. Understanding the dynamics of litter is a prerequisite for studying energy flows and nutrient cycling in forest ecosystems. The aims of the present work are therefore, to determine the rhythm of litter fall and, jointly, to evaluate the annual production by the trees.

2. Materials and methods

2.1. Study sites

The study was carried out in a plot of 1 ha chosen in the forest of Bellif, located in the North-Western of Tunisia. The average annual temperature in 2010, 2011 and 2012 was 18°C. Over those three years, the average annual rainfall was 1018.5mm. The drought period was from June to August in 2010 and from May to August during 2011 and 2012 respectively.

2.2. Litter collection

The accumulation of litter was determined at 35 litter traps (1m²) located every 15 m. These traps were raised slightly off the ground to avoid contamination. They are used to recover all the lost parts of trees and shrubs fallen to the ground: leaves, fruits, flowers, bark and twigs. The content of the trap was collected monthly and was separated into its various components, then left to dry in an oven at 75°C for 48 hours to constant weight.

2.3. Statistical analyses

The spatial variability in the litter fall collected during the study period was assessed with the calculation of the coefficient of variation (CV) between litter traps: the cumulative mass collected over the whole study period (in grammes) was calculated for each litter trap. The standard deviation of the litter trap collection values was divided by their arithmetical mean

3. Results and discussion

3.1. Results

The total litter fall was 598.95± 131.05g/m²/year in 2010, 651±146.1g/m²/year in 2011 and, 270±43.72g/m²/year in 2012 gaving an average of 497.15±198.5 g/m²/year. The highest amount of litter fall was registered in April and December 2012. Monthly litter falls ranged from 5.1 g/m² (March) to 112.2 g/m² (April) in 2010, from 12.2±2.18 g/m² (August) to 178.55 g/m² (April) in 2011 and in 2012, it extended from 12.7± 6.24 g/m² (August) to 50.9±12.07 g/m² (March). Therefore, litter production was highest during April in 2010 and 2011 and in March in 2012. Leaves were the largest litter component. (62% Quercus. suber, 8% Quercus. canariensis, 3% shrub). Twigs, catkins, necromass and acorns contributed around 10%, 7%, 1% and 9% respectively. The leaf fall of the cork oak took place all along the year with nevertheless two main peaks. The first was in spring (April for 2010 and 2011, and March for 2012), the most important in terms of biomass and the second was in autumn (from November to December in 2010 and 2011 and from September to October in 2012). Indeed, the biomasses were of the order of 94.6 g/m², 141.6 g/m² and 36.3 g/m² in spring 2010, 2011 et 2012 respectively.

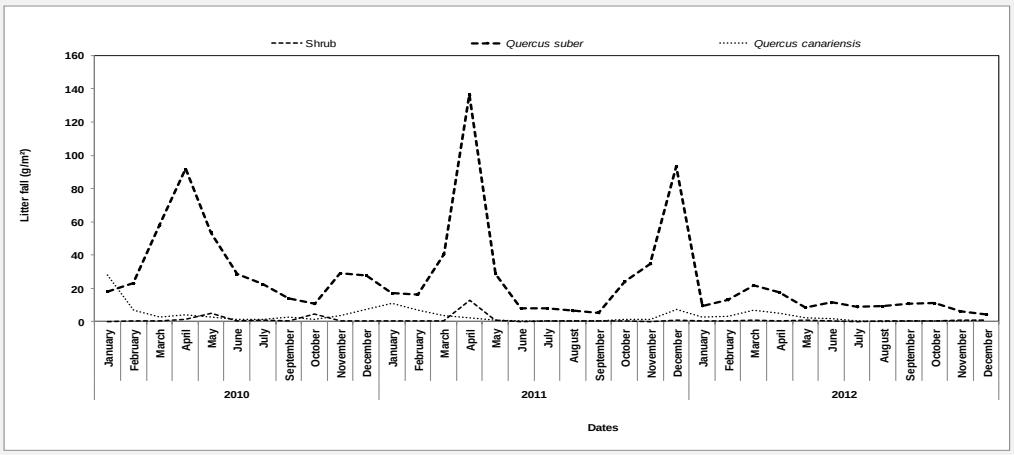

Figure 1. Time series of the litter fall components (*Q. suber*, *Q. canariensis*, shrub) from January 2010 to December 2012

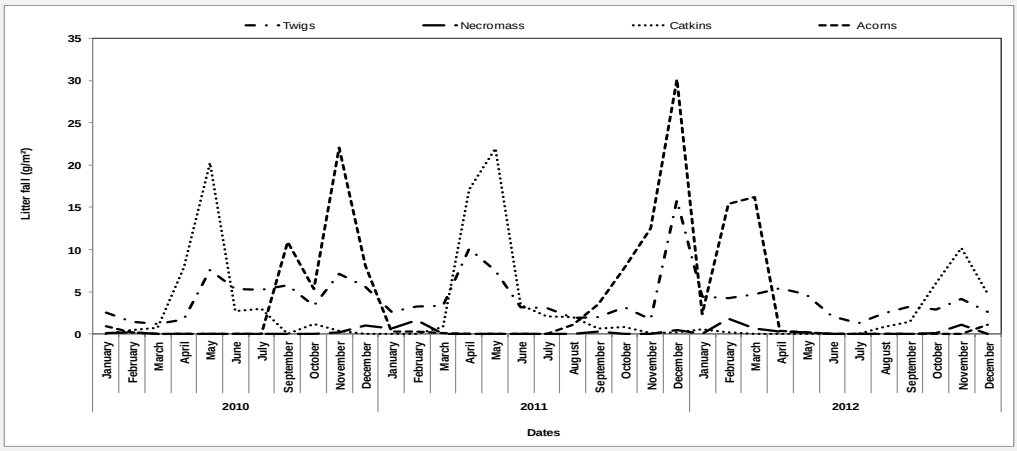

Figure 2. Time series of the litter fall components (twigs, necromass, catkins, acorns) from January 2010 to December 2012

In autumn, maximum biomass were detected in December for the three years of study. They were of the order of 28.9 g/m² in 2010, 93.5 g/m² in 2011 and 13.54 g/m² in 2012. Leaf fall fluctuated between years. It was 386.8 g/m²/year in 2010, 427.3 g/m²/year in 2011 and 132.6 g/m²/year in 2012. The Q. *canariensis* leaf fall occurred throughout the year with a single peak which occurred predominantly from the end of autumn to the end of winter, during which time the species loses most of its leaves. This offset falling leaves compared to *Q. suber* is due to character marcescent of *Q. canariensis*. Its average annual production was 62.31 g/m²/year in 2010, 35.5 g/m²/year in 2011 and 24.5 g/m²/year in 2012. The peaks were observed in January of each year with rates of 27.8 g / m² in 2010, 11.1 g/m² in 2011 and 9.1 g/m² in 2012. For the evergreen species of shrub, such as cork oak, the fall took place throughout the year, with an average annual production of 13.8 g/m²/year in 2010, 19.2 g/m²/year in 2011 and 6.5 g/m²/year in 2012 with nevertheless one pick, in spring (between April and May) (Figure 1). The values of these peaks were 4.9 g/ m² in 2010 (May), 15 g/m² in 2011 (April) and 1.34 g/m² in 2012 (April). The fall of the twigs took place throughout the year with monthly variations. An average annual production was 48.3 g/m²/year in 2010, 58.4 g/m²/year in 2011 and 42.1 g/m²/year in 2012. The peaks were detected in May (7. 6 g/m²) and November (7.4 g/m²) in 2010. In 2011, they were observed in April (10.24 g/m²) and December (15.9 g/m²). In 2012, these are the months of January and April, which showed the highest values of twigs (8.1 g/m² and 10.05 g/m²). The catkins fall occurs mainly in spring, between Aprils and May (2010, 2011, and 2012) and can extend until October. The biomasses were 37.3 g/m²/year, 51.05 g/m²/year and 24.3 g/m²/year in 2010, 2011 and 2012 respectively. The values of peaks were 20.44 g/m² (May) in 2010, 13.4 g/m² in April 2012. In 2011, these values ranged from 18.7 to 22 between the months of April and May.

3.2. Discussion

The average annual litter fall production registered in cork oak forest of Bellif (5 T/ha/year) is similar to other cork oak forest and Mediterranean oak forest (Selmi, 1985 ; Caritat et al. 2006). However, Zribi et al. (2016), in their work on the Bellif forest, they showed that annual litter production fluctuated from 8 to 13 T/ha/year under mature and young stand. In previous studies for the same species in Ain Snoussi and Khroufa forests in the North West of Tunisia, Ben Yahia et al. (2016) and Ben Yahia (2017) found an average litter production below that of Bellif of about 4T/ha/year and 3.9 T/ha/year despite the density difference. Our results shown that litter production in the evergreen species Q. suber is strongly seasonal with a major peak in spring (April-May) and another much smaller peak in autumn (October-December). Similar results have previously been reported for Q. ilex and Q. suber (Bellot et al. 1992 ; Bussotti et al. 2003 ; Rapp et al. 1999, Andivia et al. 2010 ; Caritat et al. 2006 ; Zribi et al. 2016 ; Ben Yahia et al. 2016). Litter fall seasonality is mainly determined by leaf fall (Andivia et al. 2012). It is always the leaves which contribute strongly to the litter fall forest ecosystems. In the cork oak forest of Bellif, almost all litter fall fractions have strongly seasonal fall pattern, especially leaves and flowers of all species present and acorns of Q. suber and Q. canariensis and it is similar to those found in Other Mediterranean evergreen woodlands (Caritat et al. 2006 ; Ben Yahia et al. 2016). The first fall of leaves of Q. suber in Bellif took place in the spring, in April whatever the year. However, at Ain Snoussi forest, it took place in May (Ben Yahia et al. 2016). The regular fall of leaves takes place in the spring, in April, May or June, as in normal in Mediterranean oaks, but with some variations depending on the place and the year (Selmi 1985 ; Bellot et al. 1992 ; Caritat et al. 1996 ; Caritat et al. 2006 ; Andivia et al. 2010 ; Ben Yahia et al. 2016 ; Zribi et al. 2016). The leaf fall, the bud burst and flowering were synchronous and linked to temperature (Caritat et al. 1996 ; Bou et al. 2015 ; Ben Yahia et al. 2016). The same observation was done on Q. ilex (Bou et al. 2015). This phenomen was observed in Q. ilex by Bou et al (2015).In previous studies of leaf fall in Q. suber, (Selmi 1985; Caritat et al. 2006; Aindivia et al. 2012, Zribi, 2016; Ben Yahia et al. 2016, have spoken about second leaf fall peak in autumn which is smaller than the spring in terms of biomass and rate of fall. The two peaks were observed also on Q. ilex (Bussotti et al. 2003 ; Boulmane et al. 2013, Bou et al. 2015). Such as deciduous trees, Q. canariensis have a strategy of building one-season leaves, which grow and senesce in some months. In temperate forest, in deciduous species, leaf fall is in autumn, where conditions get unfavorable for the net primary production (colder temperatures and less light) (Bou et al. 2015). However, in Mediterranean forest, leaf fall is in winter, also when the temperatures decrease and the days are short (colder temperatures and less light). The catkins fall took place from March to June with a peak in May in 2010 and 2011 and in April 2012. In Ain Snoussi forest, the pic was also in May (Ben Yahia et al. 2016). In Spain, the same

phenomenon has been observed from June to July (Caritat et al. 2006). The phenological study of Ben Yahia et al. (2016), about cork oak in Tunisia indicate that process of leaf shedding, bud burst and flowering occurs simultaneously in spring. Twig fall was not as strongly seasonal (Andivia et al. 2012 ; Ben Yahia et al. 2016) but was depend on wind and storm (Caritat et al. 2006). Regarding acorn, the fall was from July to December-January. The peak fall was in autumn-winter (November and December). The same observation was made on Q. ilex (Andivia et al. 2012 ; Bou et al.2015) and on Quercus. suber (Ben Yahia et al. 2016). Summer acorns fall was explained by the summer wind on Quercus. Ilex (Bou et al.2015).

4. Conclusion

Litter production in evergreen Quercus. Suber shows a strong seasonal pattern with peaks occurring in spring and autumn, but the greatest being in spring when temperature increase. The differences found in litter production between years seem to be related to climatic parameters (precipitations) and water availability which had an important effect on litter fall dynamics. Further long-term studies on the causes of these differences are needed to properly model the nutrient cycling in forests.

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