■ Doctoral thesis abstract

Light after death: the importance of spectral composition in litter decomposition processes

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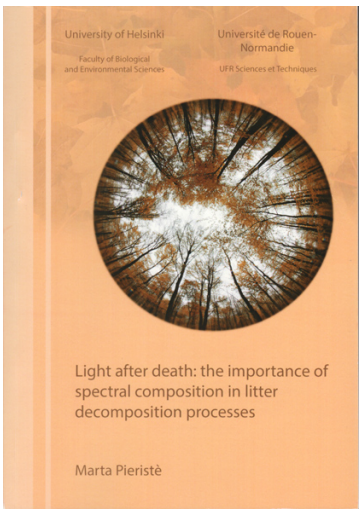
Bio of Marta Pieristè

Place of Birth: Recanati, Italy
BSc in Forest and Environmental Sciences Università Politecnica delle Marche, Ancona, Italy
MSc in Wildlife and Environmental Science and Management University of Florence, Firenze (Italy)
Thesis title: Influence of roe deer feeding sites on browsing intensity in an Austrian mountain forest (In collaboration with BOKU University, Vienna, Austria)

Research visit to Forestry and Forest Products Research Institute, Japan, Tsukuba Collaboration in 2 field studies examining plant response to sunlight and plant traits variation as a consequence of exposure to different spectral regions of sunlight.

Cooperation to the creation of the Science nature trail at Lammi Biological Station (Finland) Design of several citizen-science activities for families and young students related to forest ecology.

Short presentation I was always fascinated by nature and forests since a very young age. For this reason, I decided to study forestry and environmental management. After having the opportunity to work with different research groups during my internships in Italy and Austria, I felt like research could be my career pathway and I decided to start a PhD in Plant biology.



PhD Thesis Abstract

This dissertation focuses on the effect of sunlight on leaf litter decomposition. Sunlight can affect litter decomposition positively or negatively through the process known as photodegradation. Photodegradation is the ensemble of direct, indirect and mediated mechanisms. Short-wavelength solar radiation, carrying high energy, has the capacity to directly break down relatively stable components of plant tissues, such as lignin and cellulose, through photochemical mineralization causing the release of volatile carbon compounds into the atmosphere. Photochemical mineralization produces more-labile molecules, which can enhance the activity of microbial decomposers through a process known as photofacilitation or photopriming. Solar radiation has also the ability to indirectly alter decomposition through negative effects (photoinhibition) on both the activity and community composition of decomposer organisms.

We examined the process of photodegradation under forest canopies in

a temperate and a boreal environment. Through two field experiments, we tested the effects of photodegradation on mass loss and carbon content during leaf litter decomposition in each environment (I in France and II in Finland). We also studied these processes under controlled conditions in a filter experiment (II). In France, we performed an additional field experiment, in the same forest as the first, to analyse the effect of photodegradation on microbial assemblages colonizing the litter (III). In these experiments, we employed "photodegradation-litterbags", bespoke litterbags adapted from classical litterbags used in litter decomposition studies incorporating different types of film filter-material, allowing us to manipulate the spectral composition of sunlight. Finally, we conducted a meta-analysis (IV) to summarise the effect of photodegradation driven by different spectral regions of solar radiation at the global scale, and across different biomes, and to test whether the photodegradation rate is modulated by initial litter traits.

This dissertation highlights the importance of blue light as a major driver of photodegradation in a temperate mid-latitude forest understorey, with the potential to enhance both litter mass loss and carbon loss. However, at a higher latitude, the full spectrum of sunlight decreased mass loss, suggesting that the effect of photodegradation is specific to each biome. Forest canopies not only modify the amount of incoming solar radiation and its spectral composition, but also shape the microclimate of the understorey, producing unique combinations of temperature, moisture and snow-pack depth. Hence, each canopy generates novel interactions of solar radiation and other environmental factors which act on leaf litter to determine the photodegradation rate. At both boreal and temperate latitudes, our spectral manipulations revealed the effect of photodegradation to be litter species-specific, with recalcitrant litter experiencing higher rates of photodegradation. In terms of microbial decomposition, we highlighted how blue light, UV-A radiation and green light, act synergistically to shape the structure of microbial decomposer communities, with bacteria tending to dominate in sunlight and fungi in dark conditions.

The results of our meta-analysis show that the direction and magnitude of photodegradation are dependent on the spectral region considered. We highlight the crucial role of blue light and UV-A radiation as drivers of photodegradation across biomes. Blue light has a positive effect in enhancing mass loss, while UV-A radiation has a negative effect. Moreover, our meta-analysis shows that the rate of photodegradation at the global level is modulated by climate and ecosystem type; whereby arid and semiarid ecosystems with low canopy cover experience the highest photodegradation rates. On the other hand, initial litter traits failed to predict the rate of photodegradation on the global scale, despite being important at the local level; suggesting that different traits could be important in different biomes.

Photodegradation is known to have a role in the carbon cycle, as the process of photochemical mineralization causes the release of volatile carbon compounds into the atmosphere. Therefore, we can expect photodegrada-

tion to reduce the amount of carbon sequestered by ecosystems. However, further research is needed to estimate the actual contribution of photodegradation to the global carbon cycle. Moreover, this contribution is likely to be affected by climate change, which modifies environmental factors such as temperature and the amount and pattern of precipitation; these factors together with spectral irradiance determine the photodegradation rate.

Overall, our results show that the process of photodegradation has an effect on litter decomposition in the understorey of mid- and high- latitude forests, despite the low irradiance to which litter in these ecosystems is exposed. Blue light appears to be more important than other spectral regions in driving photodegradation in these habitats. However, the photodegradation rate is modulated by both climate and ecosystem type.

Publications in the thesis

Pieristè, M., Q.-W. Wang, T. K. Kotilainen, E. Forey, M. Chauvat, H. Kurokawa, T. M. Robson, and A. G. Jones (2020). *Crucial role of blue light as a driver of photodegradation in terrestrial ecosystems on the global scale: a meta-analysis*. Manuscript.

Pieristè, M., M. Chauvat, T. K. Kotilainen, A. G. Jones, M. Aubert, T. M. Robson, and E. Forey (2019). "Solar UV-A radiation and blue light enhance tree leaf litter decomposition in a temperate forest". In: *Oecologia* 191.1, pp. 191–203. DOI: 10.1007/s00442-019-04478-x.

Pieristè, M., E. Forey, A. L.-H. Sahraoui, H. Meglouli, F. Laruelle, P. Delporte, T. M. Robson, and M. Chauvat (2020). "Spectral Composition of Sunlight Affects the Microbial Functional Structure of Beech Leaf Litter During the Initial Phase of Decomposition". In: *Plant and Soil* 451.1-2, pp. 515–530. DOI: 10.1007/s11104-020-04557-6.

Pieristè, M., S. Neimane, T. Solanki, L. Nybakken, A. G. Jones, E. Forey, M. Chauvat, J. Ņečajeva, and T. M. Robson (2020). "Ultraviolet radiation accelerates photodegradation under controlled conditions but slows the decomposition of senescent leaves from forest stands in southern Finland". In: *Plant Physiology and Biochemistry* 146, pp. 42–54. DOI: 10.1016/j.plaphy.2019.11.005.

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