Seasonal fluctuations of the airborne pollen in Guarda (Portugal)

Inês Lisboa[1], Pedro M. S. M. Rodrigues[2], Joaquim C. G. Esteves da Silva[3]

[1,2]Escola Superior de Tecnologia e Gestão, Instituto Politécnico da Guarda, PORTUGAL
[3]Departamento de Geociências, Ambiente e Ordenamento do Território, Universidade do Porto, PORTUGAL

Abstract— *Airborne pollen calendars are useful to estimate the flowering season of the different plants as well as to indicate the allergenic potential present in the atmosphere at a given time. In this study, a 1-year survey (from January 2013 to February 2014) is presented of the atmospheric concentration of pollen types in Guarda (Portugal), using a 7-day Hirst volumetric trap. The daily mean concentration of both the number of pollen grains and the main pollen season was determined as well as the bi-hourly variations. The highest airborne pollen concentration was found during early spring and early summer. Contrastingly, December was the month with the lowest pollen concentration. The major pollens sampled were Quercus, Pinaceae, Poaceae, Cupressaceae, Urticaceae, Apiaceae, Oleaceae and Polygonaceae. Some differences were found in the intradiurnal distribution patterns of the pollen types studied, with some taxa types being predominantly sampled in the morning (8:00-10:00 a.m.) while others were more evident in the late evening hours (8-10 p.m.). Finally, these results were compared with the forecast made by the Portuguese Aerobiology Network for the central region of Portugal, revealing some significant differences in the pollination periods.*

Keywords— Aerobiology, pollen season, bi-hourly distribution.

I. INTRODUCTION

Pollen grains are biological structures produced as part of the reproductive cycle of plants, vital to the sexual reproduction and to the maintenance of species in nature. As supported in the pollination process, pollen is an important component in the air, much like carbon monoxide, sulphur dioxide, and other gases. The pollens, commonly known as "green pollutants", could be innocuous if they did not induce allergic reactions. However, when the immune system overreacts and produces antibodies, symptoms like inflammation of the skin and of the sinus airways can appear (Sicard *et al*. 2011). The severity of allergies depends on a number of variables, such us plant distribution, climatic conditions, or urbanization levels (D'Amato *et al*. 2007; Peden and Reed 2010). Depending on the sensitivity of each individual, allergenic responses can range from minor irritation to anaphylaxis, a potentially life-threatening emergency (Darrow *et al*. 2012). The presence of relatively high levels of air pollutants in city centers will modify the properties of the exposed pollen, which may be responsible for the increase of disease-related allergies in highly urbanized regions (Cuinica *et al*. 2014; Cuinica *et al*. 2015; Ribeiro *et al*. 2014; Sousa *et al*. 2012).

While allergies cannot be cured, and the treatments can only relieve allergy symptoms, the development of aerobiological studies is important for the elaboration of pollen calendars, which not only indicates the presence and prevalence of allergenic pollen in the atmosphere of a sampling area but also supports the prediction of the flowering season (Scheifinger *et al*. 2013). This knowledge is useful for clinicians in adjusting treatment procedures and for patients in taking their own prophylactic measures, such as the planning of outdoor activities (Rica, 2003). Airborne pollen monitoring can also support architectural landscape planning, for a more balanced selection of plant species that correspond to the quality of life of the population in urbanized areas (Cariñanos and Casares-Porcel 2011).

In Portugal, aerobiological studies began with Pinto da Silva in the in the mid-twentieth century (Ribeiro and Abreu 2014) and, since then, some studies have been conducted on the type and concentration of pollen present in the atmosphere of a number of cities (Abreu and Ribeiro 2005; Caeiro *et al*. 2007; Câmara 2008; Fernandes *et al*. 2010; Ribeiro *et al*. 2005). One study also considered the relationship of pollen concentrations with meteorological factors (Ribeiro *et al*. 2003).

Since 2003, the Portuguese Aerobiology Network (PANet) has been monitoring the airborne pollen and fungal spores in Portugal, namely in the cities of Oporto, Vila Real, Coimbra, Castelo-Branco, Lisboa, Évora, and Portimão (Caeiro *et al*. 2007; Nunes *et al*. 2008) with altitudes between 0 and 425 meters. However, in Guarda, the highest city in Portugal (1056 m), and one of the cities with the greatest temperature range, there are no aerobiological studies.

The main objective of this work is to eliminate this information gap, evaluate the airborne quality, and compare the results of Guarda with the pollen calendar for the central region of Portugal. Indeed, in terms of chemical air pollutants, Guarda is a city characterized by excellent air quality, and chemical pollutants are not a major problem. Hence, adverse factors in the ambient atmosphere are mainly allergens of biological origin. This study point to the relevance of airborne pollen monitoring as a tool for the measurement of air quality and for the assessment of public health.

II. MATERIAL AND METHOD

The aerobiological study was conducted in Guarda (Fig. 1), located in the centre of Portugal at 1056 m altitude, near the border with Spain (40º32'N; 7º16'W), is characterized by a wet mediterranean climate, according to the Emberger index. The average annual temperature is about 11°C and the temperature variation between the warmest and the coldest month is 42°C. The annual relative humidity varies between 50 and 90% and the total average annual rainfall is about 76 mm. The winds blow mainly from the NW quadrant (Portuguese Sea and Atmosphere Institute).

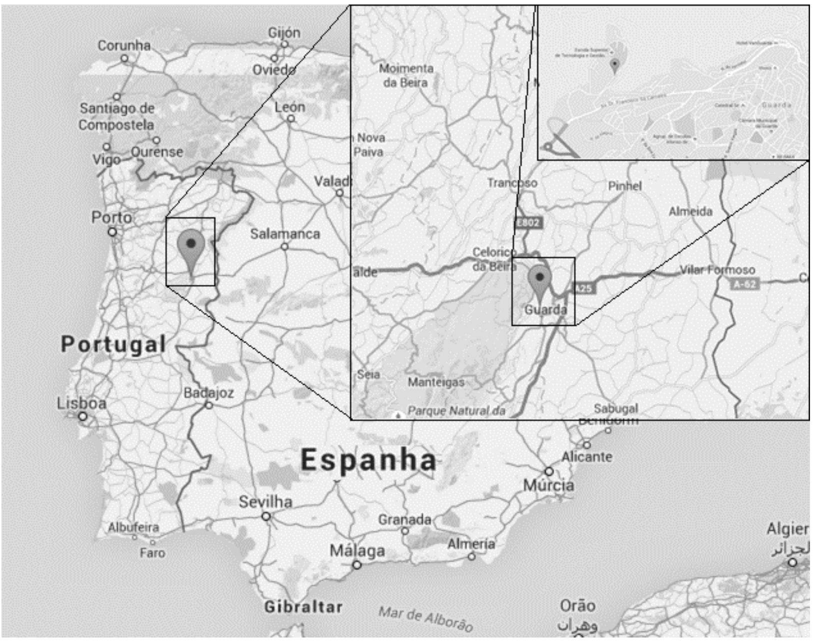

FIG. 1: LOCATION OF GUARDA CITY IN THE IBERIAN PENINSULA (SOURCE: GOOGLE MAPS)

The sampling was conducted on the campus of the Guarda Polytechnic Institute, between January 2013 and February 2014. Beside this area there are small agricultural fields and some groves of trees which are primarily oak, chestnut and pine. During 2013 there was a monthly average rainfall of 3.5 mm, with the highest rainfall occurring between September and March and the lowest rainfall between June and August. There was no rainfall during the month of August.

The equipment used in the sampling process is a Hirst volumetric trap (Hirst, 1952), placed about 1.5m above the soil, and calibrated to capture 10 liters of air per minute. The atmospheric air is sucked into the machine through a small hole, by the action of a motor, and comes into contact with a drum coated with a strip of Melinex® tape impregnated with a Gelvatol® solution (35g gelvatol and 2g phenol in 100 ml water and 50 ml glycerol).

The bi-hourly and daily average concentrations of pollen grains were determined using an optical microscope with a 400x magnification covering 12 vertical lines of 2 mm, corresponding to a time monitoring. The pollen count was subsequently converted into pollen grains per m^3.

III. RESULTS AND DISCUSSION

During the monitoring period, 18 different pollen types were detected (the most significant are listed in Table 1) with an average daily concentration, per cubic meter, of 16.7 pollen grains. The most frequent pollen types were *Quercus* (26.8%), followed by *Pinaceae* (23.5%) and *Poaceae* (12.1%). These three types of pollen represent more than 50% of the total existing pollen in Guarda. Other pollens types were also frequently observed, including *Cupressaceae*, *Urticaceae*, *Apiaceae*, *Oleaceae* and *Polygonaceae*, with a percentage ranging from 4 to 8.5.

The highest pollen concentrations were record during the period between the early spring and the early summer, where the months of April and May registered the highest monthly average concentration of pollens (in April the average concentration was 88.7 pollens/m^3). This is not surprising pollination occurs during the spring for most plants. It was also during the month of April that the highest daily value (500 pollen/m^3) was detected. This high concentration is comprised of 73.9% oak pollen, 18.2% pine pollen, and 3% sorrel pollen, which are pollens that are moderate to low allergens and thus do not present a risk for the development of allergic reactions.

There are no major changes in pollen concentration throughout the day, but slightly higher concentrations are detected between 8:00 and 10:00 a.m., with 1.64 grains of pollen/m^3, and lower concentrations between 8:00 and 10:00 p.m., with 1.21 pollen grains/m^3. Similar results were obtained in other studies, with a greater concentration in the morning and a lower concentration in the afternoon (Barnes *et al*. 2001; Zemmer *et al*. 2012; Ribeiro and Abreu 2014). This pattern may be a consequence of the sampling method, measured at 1.5 meters above the ground, and the positive effect of environmental humidity during the morning on the accumulation of pollen near the ground.

TABLE 1
FAMILY NAME, ANNUAL AVERAGE CONCENTRATION OF POLLEN GRAINS (POLLEN GRAINS/M3) AND PERCENTAGE OF THE MOST PREVALENT POLLENS IN GUARDA AIR DURING 2013 SAMPLING.

Family/genus	Total of pollen grains/m^3	Total %
Fagaceae Quercus	56.2	26.8
Pinaceae	49.3	23.5
Poaceae	25.3	12.1
Cupressaceae	17.8	8.5
Urticaceae	15.3	7.3
Apiaceae	13.9	6.6
Oleaceae	12.2	5.8
Polygonaceae	8.4	4.0
Platanaceae	3.0	1.4
Betulaceae	2.9	1.4
Fagaceae Castanea	2.2	1.1
Plantaginaceae	1.2	0.6
Compositae	1.0	0.4
Amaranthaceae	0.5	0.2

A pollen calendar was constructed by counting the number and pollen types throughout the monitoring period and the determining the average concentration over time. Most of the species in this study release their pollen grains between April and July, with the exception of pigweed (*Amaranthaceae*) and Artemisia (*Compositae*), which release the pollen later, between August and September. The birch (*Betulaceae*) and cypress (*Cupressaceae*) species exhibit different behavior, releasing pollen during the winter period. A detailed analysis of the results shows a peak concentration during April and May to nettle (*Urticaceae*), sorrel (*Polygonacea*), chestnut (*Fagaceae*), plantain (*Plantaginaceae*) and eucalyptus (*Myrtaceae*) although with different durations. Pine (*Pinaceae*), maple (*Platanaceae*) and oak (*Fagaceae*) reveal their main period of pollination to be in April and olive trees (*Oleaceae*) reach a peak of pollen concentration in June although the cypress (*Cupressaceae*) and grasses (*Poaceae*) have a long period of pollination between April and July. Fig. 2 below shows the pollen calendar obtained in this study contrasted with the pollen calendar for the Central Region of Portugal by the PANet.

The comparison of the pollen calendar obtained in this study and the pollen calendar made for the Central Region of Portugal (PANet) shows some differences. For some pollen species, such as nettle (*Urticaceae*), sorrel (*Polygonacea*), plantain (*Plantaginaceae*), eucalyptus (*Myrtaceae*), and pigweed (*Amaranthaceae*), PANet's prediction for the pollination period is longer than that observed in the present study. These differences may be due to the particular weather conditions of the region of Guarda and the high altitude. This region is characterized by an extreme climate and virtually no transition between the seasons; pollination of plants tends to occur abruptly and not gradually, as recorded in other regions of Portugal. The most restrictive factors affecting the normal development of the plants of this region are the stress caused by irregular rainfall, the extreme temperatures which cause a response that deviates from the optimum, and the high mountainous location which affects the normal growth of plants (Cariñanos *et al*. 2004). In addition, the severity and the duration of both autumn and winter determines, to a great extent, the onset of the pollination phenomenon (Frenguelli and Bricchi 1998) and helps to justify the differences between the predictions of PANet and the present study. The pollen peaks in Guarda are concentrated in fewer days than the main pollination period predicted by PANet, with the greater concentrations occurring during the warmer months, mainly for *Cupressaceae*, *Amaranthaceae* and *Poacea*.

In the specific case of the eucalyptus, this pollen appeared in minor amounts, without demonstrating a peak set, contrary to what is predicted by PANet for the centre of Portugal. To explain these results, note that eucalyptus is not an abundant specie in Guarda. Pollination periods for birch (*Betulaceae*) showed the greatest time lag since manifestation of this pollen occurs much earlier in this region than anticipated by the pollen calendar of PANet. For the Betulaceae family, the air temperature in the period preceding pollen release is decisive for the starting date of the pollen season and observations of the beginning of the pollen season show an oscillation of up to 90 days (Spieksma *et al*. 1995; Aira *et al*. 1998).

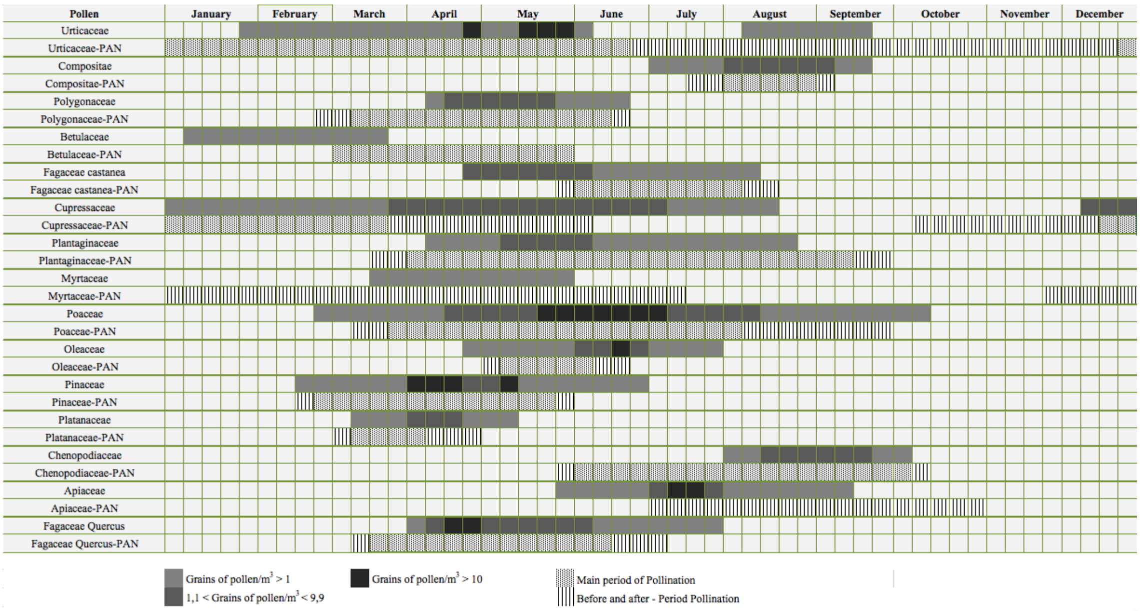

FIG. 2: DISTRIBUTION OF THE MOST PREVALENT POLLENS IN THE AIR OF GUARDA AND THE CENTER REGION OF PORTUGAL.

IV. CONCLUSION

This study reveals a relative difference to the prediction made by PANet, especially with regard to *Betulaceae*, *Fagaceae*, *Amaranthaceae*, *Cupreaceae* and *Polygonaceae*. A major difference is that the pollination period tends to be shorter, which can be beneficial in terms of allergies. These differences are primarily motivated by the high altitude at which the study was conducted and weather conditions, particularly temperature and precipitation, that are distinguishing factors from the cities used to elaborate the PANet forecasts. Vegetation may also help to explain the differences since, for example, the coastal areas of Portugal have significant eucalyptus (*Myrtaceae*) plantations, which rarely are found in the region of Guarda.

The monitoring period of one year is quite short for a consistent evaluation of the differences found with the PANet pollen calendar. Nevertheless, the work done shows that there are some important differences which need to be confirmed with longer studies. Thus, the next objective is to perform a new monitoring process for over 2-3 years.

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