

Main features of Poaceae pollen season in Madeira region (Portugal)

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Abstract

The pollinic spectrum of the Madeira region is dominated by grass pollen, which also represents an important aeroallergen in Europe. The present work aims to analyze the main features of the Poaceae pollen season in the Madeira region to determine the allergic risk. The study took place in Funchal city, the capital of Madeira Island, over a period of 10 years (2003–2012). The airborne pollen monitoring was carried out with a Hirst type volumetric trap, following well-established guidelines.

In the atmosphere of Funchal, the mean annual Poaceae pollen index was 229. The mean Poaceae pollen season lasts 275 days, with an onset date in January/March and an end date in November/December. Poaceae counts showed a seasonal variation with 2 distinct peaks: a higher peak between March and June, and the second one in autumn. The peak values occurred mainly between April and June, and the highest peak was 93 grains/m³, detected on the 27th May of 2010. The Poaceae pollen remaining at low levels during the whole growing season, presenting a nil to low allergenic risk during most of the study period. Higher critical levels of allergens have been revealed after 2006. In general, the pollen risk from Poaceae lasted only a few days per year, despite the very long pollen season and the abundance of grasses in the landscape of Madeira Island.

Keywords: aerobiology; Poaceae; main pollen season; Madeira

Introduction

The Poaceae family (grasses) is one of the most important families of flowering plants, composed of a representative number of taxa with great significance and usefulness to humans and domestic animals. In the Mediterranean landscape, grasses dominate the herbaceous vegetation [1], being a common element in the urban areas. Grasses are both annual and perennial herbs, and most species are anemophilous [2], producing large amounts of pollen grains during a short period of time [3]. From the clinical point of view, their pollen is considered one of the most important aeroallergens in Europe [4,5] and a major cause of pollinosis in several parts of the world [6–8]. In Portugal, Poaceae pollen is one of the most frequent aeroallergens and the main cause of pollinosis in the sensitized population [9,10]. In the particular case of Madeira, Poaceae also represents one of the main pollen types in the atmosphere, along with Urticaceae pollen type [11].

The genera that cause pollinosis belong to Pooideae, Chloridoideae and Panicoideae subfamilies, which comprise among others grasses such as timothy (*Phleum pratense*),

orchard grass (*Dactylis glomerata*), meadow foxtail (*Alopecurus pratensis*), and cultivated rye (*Secale cereale*) [8]. The allergenicity of Poaceae pollen might be higher due to the cross reactivity phenomenon [12], either between grasses species or between the pollen of grasses and from other unrelated plants, such as *Olea*, *Parietaria*, and *Platanus* [13]. Overall, the threshold concentration of 30 grains/m³ in the air is the value above which sensitized patients experience allergic symptoms [14]. However, the threshold value has been difficult to establish, varying between 10 and 50 pollen grains/m³ of air. For this reason, the Aerobiological Network of Catalonia (CAN) [15] defined a scale with several categories of risk levels for grass pollen, with a very high risk of exposure occurring when the weekly concentration exceeds 30 grains/m³. Later on in 2007, the Spanish Aerobiological Network (REA) established the threshold value of 25 pollen grains/m³ as capable of triggering serious allergy symptoms in allergic patients [16].

A common feature of pollen grains of any taxa belonging to the family Poaceae is their morphological similarity, and for this reason the whole family is considered to have a single pollen type. Therefore, the morphological uniformity of Poaceae pollen makes it very difficult to determine the pollination period for each individual species [17]. Typically, in the Mediterranean area the main grass flowering period occurs between April and August, while in northern,

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Central and Eastern Europe flowering usually starts in May and ends in July.

Considering the aerobiological and clinical importance of Poaceae pollen type, the present work aims to analyze the main features of the Poaceae pollen season in the Madeira region on a ten-year basis. The study can help to define periods when the grass pollen concentrations might exceed any clinically established threshold values, representing a useful tool for allergic patients and allergologists.

Material and methods

The present study took place in Funchal city, the capital of Madeira Island, over a period of 10 years (2003–2012). Madeira is the biggest and the main island of the Madeira Archipelago located in the Atlantic Ocean, southwest of Portugal. The climate is subtropical, with average temperatures of 18.7°C, relative humidity of 55–75%, and rainfall varying between 500 mm and 1000 mm. Funchal city offers 17 public green spaces of native and exotic plants from around the world. The most common trees are *Tipuana tipu*, *Jacaranda mimosifolia*, *Agathis robusta*, and several species of the families Arecaceae, Cupressaceae and Cyatheaceae. The urban landscape presents a variety of grasses dominated by *Arundo donax*, *Phleum*, and *Dactylis* species. In the outskirts of the city, an exotic forest dominated by *Acacia*, *Eucalyptus* and *Pinus* prevails.

The airborne pollen monitoring was performed with a Hirst type volumetric trap (Burkard Manufacturing Co. Ltd., UK), following the guidelines of the International Aerobiology Association and the recommendations proposed by the Spanish Aerobiology Network [16].

The Burkard trap was placed at the roof of the Dr. João de Almada Hospital in Funchal, 10 m above ground (32°39' N, 16°55' W; Fig. 1). The identification and counting of grass pollen grains were done using a light microscope (40×), based on 4 longitudinal transects along the slides. The Poaceae pollen concentration was calculated and expressed as the number of pollen grains per cubic meter of air (p/m^3).

The annual sum of daily airborne grass pollen concentrations was expressed as the Poaceae pollen index (PPI). The 95% method was used to determine the main pollen season (MPS) of Poaceae, which includes 95% of the seasonal pollen count [18]. The intensity of the Poaceae season was established by combining 2 criteria: (i) number of days where average daily concentrations exceeded 25 pollen grains/ m^3 (REA guidelines) [16]; (ii) application of the CAN scale [15] defined by the number of weeks of the year for each risk level (level 0: no risk, 0 pollen grains/ m^3 /week; level 1: low risk, 0.1–4.9 pollen grains/ m^3 /week; level 2: medium risk, from 5–19.9 pollen grains/ m^3 /week; level 3: high risk, from 20–29.9 pollen grains/ m^3 /week; and level 4: very high risk >30 grains/ m^3 /week).

Meteorological data for air temperature (mean, maximum and minimum), relative humidity and rainfall were provided by the Institute of Ocean and Atmosphere (IPMA) – Regional Station in Funchal, located approximately 5 km southeast of the sampling site.

Results

The mean annual PPI for Funchal reported over the ten-year period was 229, with the highest value (PPI = 576) recorded in 2009 and the lowest one in 2003 (PPI = 54).

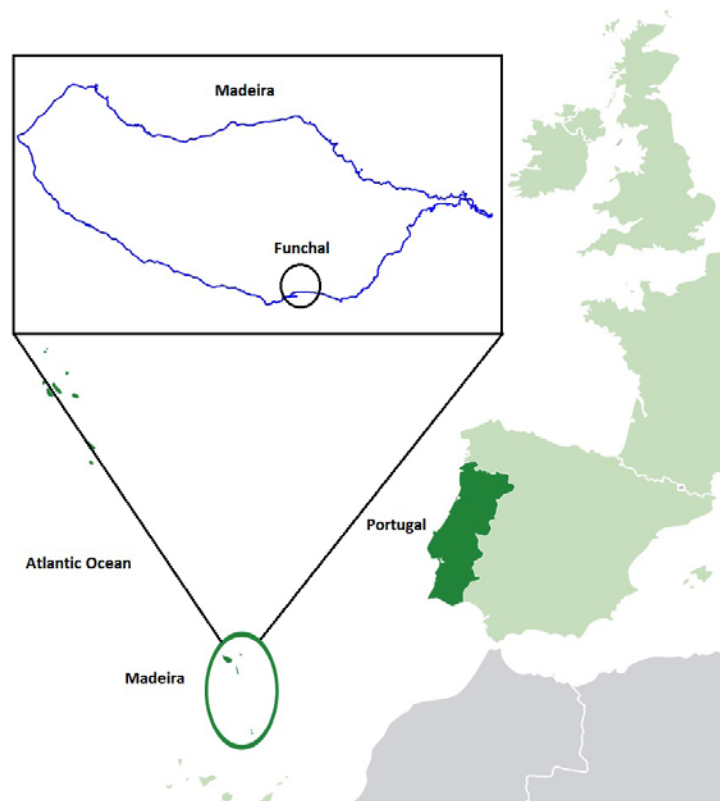


Fig. 1 Location of the pollen trap in Funchal city.

The inter-annual variations revealed a decrease in the grass pollen levels, reflected by the negative slope of the linear trend line (Fig. 2).

There was observed a marked seasonal variation in airborne grasses concentrations, with 2 annual peaks: the first and highest one occurred in spring (March to July) and a second, smaller peak in autumn (October and November).

The prevailing weather conditions recorded in Funchal during the study period showed an average temperature of 19.8°C, with maximum and minimum temperatures of 23.4°C and 17.3°C, respectively. The relative humidity had an average value of 64.1%, and precipitation reached 1.8 mm on average (Fig. 3).

The main features of the Poaceae pollen season (PPS) are summarized in Tab. 1. The PPS lasts an average of 275 days, with an onset date in January/March and an end date in November/December. The duration of the PPS ranged between 197 days in 2006 and 343 in 2003. The longest PPS was observed between 2003 and 2007, whilst the shortest periods were recorded during 2008 and 2012.

The peak values occurred mainly between April and June, and the highest peak was 93 grains/m³ detected on the 27th May of 2010.

The number of days on which the concentration of Poaceae pollen exceeded the allergic risk thresholds was a total of 43 days during the study period. The number of weeks for each category of allergenicity as proposed by CAN scale is shown in Tab. 2.

Poaceae presented a nil to low allergenic risk during most of the study period, revealing higher critical levels of allergens (high and very high categories) after 2006.

Discussion

Madeira Island has geo-climatic conditions that favor adaptation and flowering of several native and allochthonous plants throughout the year. The pollinic spectrum of Funchal city is dominated by ruderal grasses which represent a common component of the urban landscape.

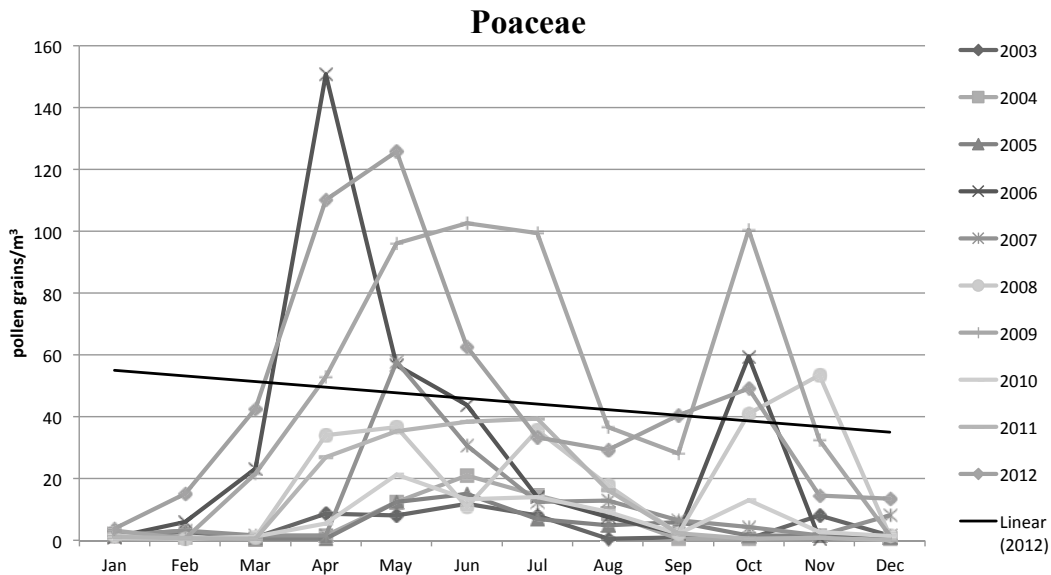


Fig. 2 Annual variations of Poaceae pollen concentrations in Funchal city.

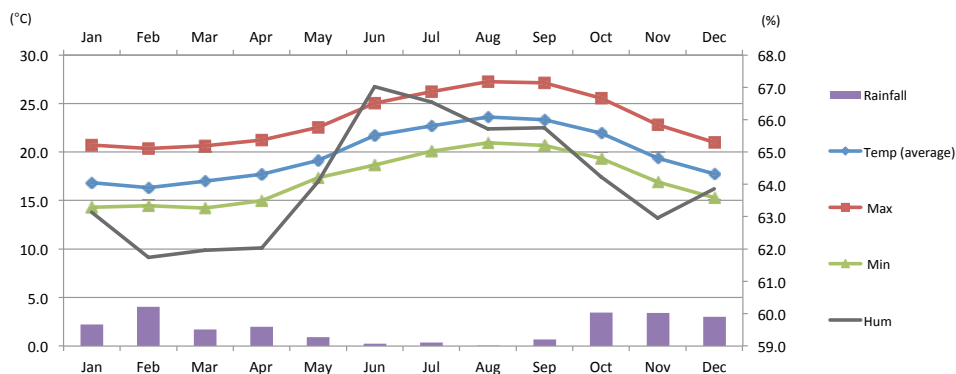


Fig. 3 Prevailing weather conditions recorded during the study period in Funchal city: minimum, average and maximum temperature, relative humidity and rainfall.

Tab. 1 Main characteristics of the Poaceae pollen season in Funchal.

Year	Grass pollen index	Representation for total pollen (%)	Main pollen season			Peak value		
			start	end	duration (days)	grains/m ³	date of peak-day	number of days >25 grains/m ³
2003	54	10.8	09-01-2003	18-12-2003	343	4.86	30-06-2003	0
2004	65	14.4	11-01-2004	12-11-2004	306	8.64	25-06-2004	0
2005	56	9.1	11-01-2005	29-11-2005	322	8.64	25-06-2005	0
2006	367	13.0	01-05-2006	14-11-2006	197	39.42	01-09-2006	1
2007	143	18.9	12-02-2007	27-12-2007	318	54.00	24-05-2007	1
2008	86	22.4	05-04-2008	07-11-2008	216	30.78	05-04-2008	3
2009	163	13.4	16-03-2009	09-11-2009	238	27.54	04-04-2009	1
2010	237	0.9	19-03-2010	23-11-2010	249	93.00	27-05-2010	33
2011	576	3.8	01-01-2011	03-11-2011	306	32.94	26-06-2011	2
2012	540	14.6	01-03-2012	08-11-2012	252	41.04	30-07-2012	2

Tab. 2 Number of weeks for each category of allergenicity.

Year/Category	Nil	Low	Medium	High	Very high
	0	0.1–4.9	5–19.9	20–29.9	>30
	0	1	2	3	4
2003	31	18	3	0	0
2004	29	20	3	0	0
2005	22	28	2	0	0
2006	23	15	10	1	4
2007	23	23	5	0	1
2008	23	19	5	2	3
2009	15	12	13	7	5
2010	4	4	18	3	23
2011	13	17	14	3	5
2012	6	13	17	5	12

In the present survey the mean Poaceae pollen index found in Funchal (229) is lower compared to other areas bioclimatically related to the Madeira region like the Canary Islands [19] and Palma de Mallorca in Spain [20], or even Portugal mainland [10].

The decreasing trend in the PPI along the years observed in Funchal during the ten-year period (Fig. 2) is in accordance with the reports from other regions [21,22], but contrary to other studies [5,23]. Poaceae pollen was observed during all the year, especially in spring when most grass species bloom [24]. The period when higher pollen concentrations occurs is similar to that observed in Portugal mainland [10] and to some regions of the Mediterranean area such as Spain, France, Italy, Greece, and Turkey [25,26]. In other Mediterranean localities it continued until September and October [26].

Regarding the onset and duration of the main pollen season, Poaceae pollen appears in the atmosphere from March until November (on average 275 days), having a longer pollen season than in other European sites [27]. However, Poaceae shows the highest concentrations in May and June and was found to have a continued presence in the atmosphere just like in most European cities [10,20].

It is likely that the good climatic conditions reported in Madeira Island (Fig. 3), with mild temperatures all the year round, favor the development of several grass species with overlapping phenologies and pollen seasons. Also, in comparison to other Portuguese cities, the duration of the main Poaceae pollen season was longer; it varies between 75 and 150 days in the north and center of Portugal (Porto, Coimbra, Lisboa, and Portimão), and under 75 days as in the case of Évora (inland center) [10].

The pollination period of grasses in Northern, Central and Eastern European regions occurs normally in early May and ends in late July. In the Mediterranean area, the flowering season begins and usually ends earlier [8], which is consistent with the scenario observed in this study.

The number of days in which the concentration of Poaceae pollen exceeded the allergic risk thresholds during the 10 years (43 days) was low comparatively to other Portuguese cities [10], with an outstanding value of 33 days in 2010. In fact, the wettest periods of the study were reported during the winter of 2009 and 2010. Furthermore, the grass pollen index found after 2010 increased and the peak pollen concentrations were reported especially in the summer. Because rainfall and temperature are important factors that control the amplitude of grass pollen seasons [4], rainfall during the months prior to the Poaceae pollen season onset, as observed in Funchal, seems to favor the growth of grasses in the summer and higher pollen production [24,28,29].

According to the CAN scale, the allergic risk from Poaceae during the study period was in general nil to low, reaching high or very high risk levels after 2006. In fact, the prevalence of sensitization to Poaceae pollen among allergy patients in the Madeira region is relatively high, at 47% [30]. This finding means that despite the pollen prevalence being relatively low for this pollen type, the risk levels can

increase over the coming years. Moreover, the triggering of allergic symptoms will also depend on genetic predisposition of the population in addition to the degree of exposure to aeroallergens [26].

This study is particularly valuable to patients sensitized to grass pollen. Hay fever sufferers and medical professionals can benefit from the information provided, by reducing the exposure to Poaceae pollen during peak periods and adopting preventive measures when planning outdoor activities.

Conclusions

- (i) The Poaceae pollen counts remain at low levels in the atmosphere of Funchal compared to other Portuguese regions or bioclimatically related areas.
- (ii) Poaceae pollen was observed during all the year, especially in spring, showing a decreasing trend in the PPI over the study period.
- (iii) The duration of the main Poaceae pollen season lasted on average 275 days, which is a longer pollen season than in other European sites.
- (iv) The risk from Poaceae lasted only a few days per year, although the very long pollen season and the abundance of plants may affect allergy sufferers.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: set up the experimental design, performed the aerobiological monitoring and wrote the manuscript: IC; wrote the manuscript: RCa; performed the statistical analysis: RCa.

Competing interests

No competing interests have been declared.

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Cechy sezonu pyłkowego Poaceae w regionie Madery (Portugalia)

Streszczenie

Pyłek traw stanowi jeden z głównych aeroalergenów w Europie. W pracy analizowano główne cechy sezonu pyłkowego Poaceae w powietrzu miasta Funchal, stolicy wyspy Madera (Portugalia). Monitoring pyłku prowadzono zgodnie z ustalonymi wytycznymi przy użyciu aparatu wolumetrycznego typu Hirsta, przez okres 10 lat (2003–2012). W okresie badań średnia roczna suma pyłku Poaceae wynosiła 229. Średnia długość sezonu pyłkowego Poaceae trwała 275 dni; początek sezonu przypada w styczniu/marcu, a koniec w listopadzie/grudniu. Stężenie pyłku Poaceae wykazywało zmienność sezonową, z dwoma wyraźnymi maksimumami: wiosennym (marzec/czerwiec) oraz jesiennym (październik/listopad). Maksymalne stężenie wynoszące 93 ziaren/m³ zanotowano 27 maja 2010 roku. Główny sezon pyłkowy Poaceae występuje wiosną, jednak przez większą część okresu badań pyłek Poaceae wykazywał niskie stężenie w ciągu całego okresu wegetacji, stwarzając zerowe lub niskie zagrożenie alergiczne. Wyższe krytyczne wartości stężeń pyłku Poaceae zaobserwowano po roku 2006. Pomimo licznych zbiorowisk ruderalnych z przewagą traw w krajobrazie wyspy oraz bardzo długiego sezonu pyłkowego, zagrożenie pyłkiem Poaceae dla osób wrażliwych trwało jedynie kilka dni w ciągu roku.