Estudo aerobiológico de Beja (Sul de Portugal)

Aeropalynological assessment of Beja (South Portugal)

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RESUMO

Introdução: A cidade de Beja (Sul de Portugal, Baixo Alentejo) não foi anteriormente estudada aerobiologicamente. **Objectivo:** Analisar e caracterizar o conteúdo polínico da atmosfera da cidade de Beja durante um período de dois anos. **Material e métodos:** A atmosfera da cidade de Beja foi estudada aerobiologicamente de Janeiro de 2003 a Janeiro de 2005, utilizando um captador volumétrico, tipo Hirst, colocado a 13 metros acima do nível do solo. **Resultados:** Foram identificados 62 tipos polínicos, 22 dos quais estiveram presentes na atmosfera pelo menos 50 dias, em pelo menos um dos anos de estudo. A concentração média anual de pólen foi de 135 grãos de pólen/m^3 em 2003 e de 85 grãos de pólen/m^3 em 2004. A maioria do pólen identificado (76%) pertence a quatro tipos polínicos que, em ordem decrescente, são: Poaceae, *Quercus* spp., *Olea europaea* e Cupressaceae. A concentração polínica média mensal mais elevada foi obtida no mês de Maio, com valores médios de 1069 grãos de pólen/m^3 em 2003 e de 466 grãos de pólen/m^3 em 2004, tendo sido a concentração diária máxima registada, em 2003, de 2485 grãos de pólen/m^3 de Poaceae e, em 2004, de 1198 grãos de pólen/m^3 de *Olea europaea*. A flora ornamental da cidade foi monitorizada, tendo-se identificado 6633 árvores ornamentais pertencentes a 58 espécies. **Conclusão:** Com a primeira avaliação aerobiológica de Beja elaborou-se um primeiro esboço de calendário polínico da região. As diferenças entre os dois anos deveram-se, maioritariamente, ao tipo polínico Poaceae, cuja concentração foi três vezes mais elevada em 2003 relativamente à obtida em 2004, provavelmente devido à maior pluviosidade em Abril de 2003 que favoreceu o crescimento e a produção de pólen de gramíneas, o mesmo se aplicando a outras herbáceas. No ano de 2003 encontrámos ainda uma correlação estatisticamente significativa entre o número de árvores ornamentais e o pólen presente no ar pertencente aos tipos polínicos que incluem essas espécies arbóreas.

Palavras-chave: Aerobiologia, Alentejo, árvores, Beja, pólen, Portugal.

ABSTRACT

***Introduction**: The city of Beja in the Baixo Alentejo, Southern Portugal has not been previously aerobiologically studied. **Aim:** To study and characterise the airborne pollen concentration in Beja for a period of two years. **Material and methods:** The atmosphere of Beja was studied aerobiologically from January 2003 to January 2005, using a Hirst volumetric sporetrap placed 13 m above ground level. **Results:** Sixty-two pollen types were identified, 22 of which were present for at least 50 days, in at least one of the years. The mean annual pollen concentration was 135 pollen grains/m^3 for 2003 and 85 pollen grains /m^3 for 2004. Most of the pollen (76%) was from four types – in decreasing order: Poaceae, Quercus spp., Olea europaea, and Cupressaceae. May was the month with the highest mean pollen concentration, with mean values of 1069 pollen grains /m^3 in 2003 and 466 pollen grains /m^3 in 2004, and a daily pollen peak of 2485 pollen grains /m^3 for Poaceae in 2003, and 1198 pollen grains /m^3 for Olea europaea in 2004. The ornamental flora of the city was recorded, and a total of 6633 ornamental trees belonging to 58 species were identified. **Conclusions:** This first aerobiological assessment of Beja allowed the draft of a preliminary pollen calendar. The differences between the two years were mainly due to the Poaceae pollen type, which had a threefold higher value in 2003, compared to 2004, probably due to the more intense April rains in 2003 that favoured the growth and pollen production of grasses and other herbaecea. In 2003, there was also a statistically significant correlation between the number of ornamental trees and their respective airborne pollen in the air of the city.*

***Key-words:** Aerobiology, airborne pollen, Alentejo, Beja, trees, Portugal.*

INTRODUCTION

The first aerobiological studies in mainland Portugal were carried out by Pinto da Silva, beginning in 1949, using a Durham sampler in Sacavém, Lisboa, and Porto[1,2]. Later, the air of Coimbra, Aveiro, Lisboa, and Porto was analysed with a Durham and Morrou sampler[3,4,5,6], and that of Braga, Porto, Reguengos de Monsaraz and Elvas, during 1998-2004, using a Cour sampler[7].

Using a Hirst type sporetraps, Clode *et al.* analysed the atmosphere of Lisbon, in 1992[8]; Todo-Bom *et al.* the atmosphere of Porto, Coimbra, Lisboa, Évora, and Portimão, between 2002 and 2004[9]; Caeiro *et al.* the atmosphere of Porto, Coimbra, Lisboa, Évora, and Portimão, between 2002 and 2006[10]; and Ribeiro *et al.* analysed the atmosphere of Porto, between 2003 and 2007[11]. Other studies have been mainly allergy oriented, with a comparison of Évora and Cordoba, in 2001[12].

Beja is located in the SW of the Iberian Peninsula. In this area, apart from the Portuguese towns that have been studied aerobiologically (Lisboa, Évora, Elvas, Reguengos de Monsaraz, and Portimão), there have been studies in Spain, in Badajoz, Merida, Seville and Huelva. Nevertheless, the coastal towns (Lisboa, Portimão, and Huelva) have quite different climates from the continental towns (Beja, Évora, Elvas, Reguengos de Monsaraz, Badajoz, and Merida).

The aims of this study are to present the first aerobiological assessment of Beja, to draft a preliminary pollen calendar for this town, to compare its airborne pollen data with the nearest stations, to find out the interannual differences and to know the correlation value between the abundance of ornamental trees in the city and the presence of their pollen in the atmosphere. Furthermore this study aims to be of useful in the area of Immunoallergology and can be applied not only in the Baixo Alentejo but also in surrounding places.

MATERIAL AND METHODS

Study area

The city of Beja (38° 01' N, 7° 87' W) is the capital of the Baixo Alentejo of Portugal (Figure 1), a peneplain of 200-300 m above sea level. It lies at a distance of 15 km from the Guadiana River and 100 km from the Atlantic Ocean. It has a typical Mediterranean climate, with an annual mean temperature of 16.1°C, and a mean annual rainfall of 605.6 mm (average values corresponding to 1951-80) distributed mainly from October to March, with hardly any rain in the hottest summer months of June, July, and August. The wind speed is about 15 km/h on average, with little seasonal variation, and the wind direction is predominantly SW[13].

The city has a population of about 23 000 inhabitants, and the district reaches nearly 36 000 inhabitants. The main economic activity is agriculture, with wheat, olives, and grapes being the major crops. Only 4% of the area of Beja

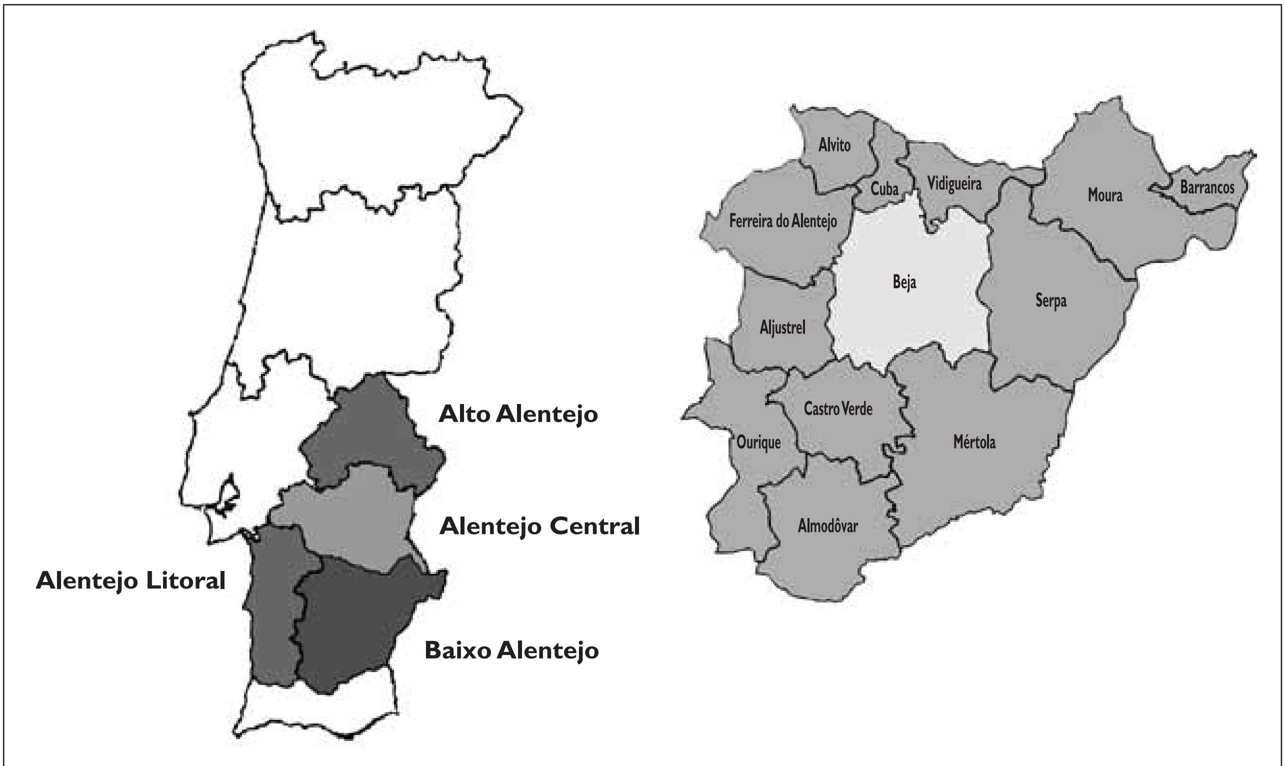

Figure 1. Alentejo region in Portugal and location of Beja district in Baixo Alentejo

district (1146.5 km²) has a natural or near natural vegetation cover, mainly cork trees and Mediterranean scrub.

Sampling

A 7-Day Recording Hirst Volumetric Spore Trap (Burkard Scientific Manufacturing – England) sampler was used, placed at 13 m above ground level in the Superior Agrarian School of Beja. Beja's meteorological station is at a distance of 1 km from the sampling site. Sampling was carried out from the 20th January 2003 to the 20th January 2005. The sampler failed to function correctly on 12 days (5-6/6/2003, 22-27/6/2003, 6-8/7/2003, 24/7/2003), so that a total of 720 days were sampled. White petrolatum was used as adhesive. Four longitudinal scans were analysed on each slide at optical microscopy (400 X). Following the REA (Red Española de Aerobiología – Aerobiologic Spanish Network) recommendations[14] and the suggestions given by Tormo *et al.*[15], a plastic film with lines 2 mm apart placed on the back of the slide was used to determine hourly counts.

Ornamental flora

The city's ornamental flora was recorded during 2002, including all the ornamental trees in streets, squares, and public gardens. Samples were registered in the Herbarium of the Superior Agrarian School of Beja. A comparison was made between the number of ornamental trees and the pollen record using the annual indices for each one of the ornamental tree pollen types selected. For this purpose, a total of 17 pollen types were defined. In alphabetical order they were: *Acacia* spp. (*Acacia dealbata, A. melanoxylon*); *Acer negundo*; Arecaceae (*Phoenix canariensis, Washingtonia filifera*); Casuarina (*Casuarina cunninghamiana, C. equisetifolia*); *Celtis australis*; Cupressaceae (*Calocedrus decurrens, Chamaecyparis lawsoniana, Cupressus arizonica, C. macrocarpa, C. sempervierens, Thuja plicata*); *Fraxinus* sp.- *Phillyrea* spp. (*Fraxinus angustifolia*); *Morus* spp. (*Morus alba, M. nigra*); Myrtaceae (*Eucalyptus camaldulensis*); *Olea europaea*; *Pinus* spp. (*Pinus halepensis, P. pinea*); *Platanus hispanica*, *Populus* spp. (*Populus alba, P. nigra, P. x canadensis*); *Prunus* spp. (*Prunus cerasifera, P. dulcis, P. persica*); *Salix babylonica*; *Tilia* spp. (*Tilia americana, T. platyphyllos, T. tomentosa*); *Ulmus minor*. The data were normalized by a $\log_{10}$ transformation and subjected to a regression analysis. The tree species considered as ornamental that are not included in these pollen types are either of low abundance in the city, or of such importance in the surrounding natural vegetation that they could not be used in this correlation study (for example, *Quercus suber*).

RESULTS

A total of 6633 of ornamental trees were counted belonging to 58 species[16,17]. The most abundant were *Celtis australis* (23%), *Cupressus sempervirens* (18%), and *Melia azedarach* (10%). Nevertheless, as a group, Cupressaceae were represented by 1327 trees of 6 species. There were 605 other trees of great aerobiological interest: *Olea europaea* (232), *Platanus hispanica* (213), and *Pinus pinea* (160).

The annual mean temperature was 0.5 °C higher than the reference values (16.05 °C) in both years studied, and the monthly temperatures were also equal to or higher than the reference values (9.5-23.8 °C). Particularly notable was June 2004, with 4°C higher than the mean values (20.7 °C). Annual rainfall in both years was lower than the reference value (605.6 mm). Monthly rainfall in April 2003 (96.6 mm) was about twice the normal monthly value (48.9 mm), and was also higher than normal in October of both years studied (67 mm). The mean wind speeds were always less than 9 km/h, slower than normal (15.3 km/h). Wind directions were predominantly NW and SW, with NW wind being stronger from April to September, and NE and SE winds appearing mainly in November-December and January-March, but not much stronger than the NW winds.

A total of 62 pollen types were identified (Tables 1 and 2), 22 with at least 50 days presence in one of the years analysed (Table 3). The annual index showed a reduction of 37% from the first to the second year, mainly due to the decline in the Poaceae pollen type, notwithstanding the higher counts, in the second year, of several of the other most important pollen types (Brassicaceae, Ericaceae, *Fraxinus* sp. – *Phillyrea* spp., *Pinus* spp., Cupressaceae, *Olea europaea*)

Table 1. Monthly and annual indices (sums of daily pollen concentrations) for the pollen types recorded in 2003

Pollen type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Alnus glutinosa	92	35	0	0	0	0	0	0	0	0	0	3	132
Fraxinus sp. – Phillyrea spp.	13	4	2	0	0	0	0	0	0	0	7	144	170
Ulmus minor	5	5	5	1	0	0	0	0	0	0	0	0	16
Corylus avellana	4	0	0	0	0	0	0	0	0	0	0	0	4
Mercurialis spp.	0	2	0	0	0	0	0	0	0	0	0	1	3
Cupressaceae	284	635	798	24	20	1	1	0	1	7	14	24	1809
Platanus hispanica	0	0	511	114	72	0	0	0	0	0	0	0	697
Urtica membranacea	35	79	387	238	274	2	1	0	1	0	0	4	1021
Salix spp.	0	4	40	6	0	0	0	0	0	0	0	0	50
Populus spp.	3	16	23	3	0	0	0	0	0	0	0	0	45
Quercus spp.	0	0	298	4125	2743	99	29	25	25	4	19	35	7402
Pinus spp.	2	6	127	376	128	20	11	10	7	1	1	0	689
Celtis australis	0	0	22	132	65	1	0	0	0	0	0	0	220
Acer negundo	0	0	21	86	70	0	0	0	0	0	0	0	177
Morus spp.	0	0	5	75	1	0	0	0	0	0	0	0	81
Brassicaceae	0	0	23	28	10	2	1	1	0	0	0	0	65
Acacia spp.	0	1	0	2	0	0	0	0	0	0	0	0	3
Juglans regia	0	0	0	1	1	0	0	0	0	0	0	0	2
Sanguisorba spp.	0	0	0	1	0	0	0	0	0	0	0	0	1
Poaceae	6	6	59	406	21023	1678	437	234	109	17	14	5	23994
Olea europaea	0	0	0	14	5222	164	17	44	10	4	1	0	5476
Plantago spp.	0	0	11	136	639	39	10	5	7	2	2	0	851
Rumex spp.	9	20	137	350	558	8	4	1	1	0	0	0	1088
Amaranthaceae-Chenopodiaceae	0	0	4	19	523	232	69	41	65	4	1	1	959
Rosaceae *p. p.*	0	0	4	70	428	2	0	0	0	0	0	0	504
Echium spp.	0	0	1	25	213	38	9	6	1	0	0	0	293
Lactuceae	0	0	10	14	188	66	14	5	6	1	0	0	304
Parietaria spp.- Urtica p. p.	7	10	31	68	160	32	36	11	12	3	15	49	434
Arecaceae	0	0	0	0	148	16	2	3	1	0	0	0	170
Anthemidae p. p.	2	0	1	10	84	20	6	1	0	0	0	1	125
Lamiaceae	0	1	0	1	63	3	0	1	0	0	0	0	69
Ericaceae	0	0	24	8	56	2	0	1	3	0	2	0	96
Prunus spp.	0	0	0	3	56	0	0	0	0	0	0	0	59
Scirpus holoschoenus	0	0	4	8	53	30	12	0	1	0	0	0	108
Spartium junceum	0	0	0	0	27	0	0	0	0	0	0	0	27
Genisteae	0	0	0	8	19	0	0	0	0	0	0	0	27
Papaver rhoeas	0	0	0	0	14	11	1	0	0	0	0	0	26
Ligustrum spp.	0	0	0	1	9	0	0	0	0	0	0	0	10
Juncaceae	0	0	1	1	7	6	0	0	0	0	0	0	15
Liliaceae	0	0	0	0	6	1	0	0	2	0	0	0	9
Cistus ladanifer	0	0	0	1	5	0	0	0	1	0	0	0	7
Pistacia lentiscus	0	0	0	0	3	0	0	0	0	0	0	0	3
Galium aparine	0	0	0	2	3	0	0	0	0	0	0	0	5
Nerium oleander	0	0	0	0	2	0	0	0	0	0	0	0	2
Anthyllis hamosa	0	0	0	0	2	2	1	0	0	0	0	0	5
Borago officinalis	0	0	0	0	1	0	0	0	0	0	0	0	1
Apiaceae	0	0	5	4	60	76	17	11	7	0	0	0	180
Castanea sativa	0	0	1	0	9	55	8	6	1	0	0	0	80
Cannabis sativa	0	0	0	2	11	31	4	5	1	0	0	0	54
Typha domingensis	0	0	0	0	1	23	2	2	2	0	0	0	30
Xanthium spinosum	0	0	1	0	0	16	10	13	7	0	0	0	47
Typha latifolia	0	0	0	0	0	2	0	0	0	0	0	0	2
Tilia spp.	0	0	0	0	0	2	0	0	1	0	0	0	3
Myrtaceae	3	0	2	3	98	361	693	23	20	2	6	3	1214
Calendula sp. – Helianthus sp.	0	0	1	0	2	17	13	18	10	2	0	0	63
Casuarina spp.	0	0	0	17	4	0	0	0	142	5	3	1	172
Daphne gnidium	0	0	0	0	0	0	0	1	2	0	0	0	3
Hedera helix	0	0	0	0	0	0	0	0	0	0	0	2	2
Artemisia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Buxus sempervirens	0	0	0	0	0	0	0	0	0	0	0	0	0
Paronychia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Not identified	0	5	7	19	72	10	2	4	12	0	0	0	131
Total (daily concentrations sums)	465	829	2566	6402	33155	3073	1410	472	458	52	85	273	49242

Table 2. Monthly and annual indices (sum of daily pollen concentrations) for the pollen types recorded in 2004

Pollen type	J	F	M	A	M	J	J	A	S	O	N	D	Total
Fraxinus sp. – Phillyrea spp.	94	19	5	3	3	0	0	0	0	0	6	49	179
Alnus glutinosa	65	8	0	0	0	0	0	0	0	0	0	0	73
Paronychia spp.	24	0	0	0	0	1	0	0	0	0	0	1	26
Cupressaceae	253	1597	504	20	6	6	1	0	4	2	14	11	2418
Ulmus minor	2	8	5	0	0	0	0	0	0	0	0	0	15
Pinus spp.	1	55	576	324	83	55	11	6	2	5	5	0	1123
Platanus hispanica	0	0	384	173	5	0	0	0	0	0	0	0	562
Salix spp.	0	0	80	8	0	0	0	0	0	0	0	0	88
Mercurialis spp.	0	13	19	5	6	1	0	0	0	0	0	1	45
Populus spp.	0	7	16	3	0	0	0	0	0	0	0	0	26
Ruta angustifolia	0	0	1	0	0	0	0	0	0	0	0	0	1
Quercus spp.	13	12	683	3571	809	175	29	15	13	0	2	2	5324
Rumex spp.	6	76	232	302	163	26	1	3	0	0	0	0	809
Plantago spp.	0	0	8	301	295	95	8	4	1	1	0	0	713
Urtica membranacea	8	43	173	198	41	9	2	0	0	0	0	8	482
Acer negundo	0	2	45	72	4	0	0	0	0	0	0	0	123
Parietaria spp.- Urtica p. p.	44	24	46	57	40	15	9	4	2	0	8	9	258
Celtis australis	0	0	7	40	1	0	0	0	0	0	0	0	48
Morus spp.	0	1	33	36	4	0	0	0	0	0	0	0	74
Brassicaceae	0	3	17	27	11	9	2	0	0	0	0	1	70
Corylus avellana	0	1	1	10	3	0	0	0	0	0	0	0	15
Juglans regia	0	0	2	10	1	1	0	0	0	0	0	0	14
Spartium junceum	0	0	0	9	0	0	0	0	0	0	0	0	9
Papaver rhoeas	0	0	0	6	5	0	0	0	0	0	0	0	11
Sanguisorba spp.	0	0	0	6	1	1	0	0	0	0	0	0	8
Juncaceae	0	0	1	5	4	2	0	0	0	0	0	0	12
Anthyllis hamosa	0	0	0	2	0	0	0	0	0	0	0	0	2
Prunus spp.	0	0	0	4	3	0	0	0	0	0	0	0	7
Buxus sempervirens	0	0	0	1	0	0	0	0	0	0	0	0	1
Cistus ladanifer	0	0	0	1	0	1	0	0	0	0	0	0	2
Olea europaea	0	0	0	179	6416	366	20	5	4	0	0	0	6990
Poaceae	6	15	220	480	5501	1457	307	49	24	14	6	4	8083
Rosaceae *p. p.*	0	0	0	170	230	0	0	0	0	0	0	0	400
Pistacia lentiscus	0	0	11	15	136	0	0	0	0	0	0	0	162
Echium spp.	0	0	2	43	92	26	0	0	0	0	0	0	163
Arecaceae	0	0	1	4	49	22	4	1	0	0	0	0	81
Lamiaceae	0	1	0	30	35	3	0	0	0	0	0	0	69
Ericaceae	0	8	25	15	33	15	2	0	1	0	0	1	100
Anthemidae p. p.	1	4	6	17	31	25	1	1	0	0	0	3	89
Nerium oleander	0	0	0	2	3	0	0	0	0	0	0	0	5
Acacia spp.	0	0	0	0	3	0	1	0	0	0	0	0	4
Ligustrum spp.	0	0	0	0	3	1	0	0	0	0	0	0	4
Borago officinalis	0	0	0	0	2	1	0	0	0	0	0	0	3
Genisteae	0	0	0	0	1	0	0	0	0	0	0	0	1
Amaranthaceae-Chenopodiaceae	0	1	0	33	256	402	71	39	36	10	2	1	851
Myrtaceae	2	2	2	3	4	326	277	10	1	0	0	0	627
Lactuceae	0	0	1	12	73	86	10	4	2	1	0	0	189
Apiaceae	0	0	0	2	8	68	13	4	3	0	0	0	98
Typha domingensis	0	0	0	1	0	46	7	2	0	0	0	0	56
Scirpus holoschoenus	0	0	1	5	21	41	5	1	0	0	0	0	74
Liliaceae	0	0	3	6	7	25	13	4	0	0	0	0	58
Cannabis sativa	0	0	0	0	1	5	1	0	0	0	0	0	7
Typha latifolia	0	0	0	0	0	2	0	0	0	0	0	0	2
Galium aparine	0	0	0	1	1	2	0	0	0	0	0	0	4
Tilia spp.	0	0	0	0	0	1	0	0	1	0	0	0	2
Castanea sativa	0	0	0	0	0	29	45	2	2	0	0	0	78
Calendula sp. – Helianthus sp.	0	0	0	1	2	20	23	1	5	1	1	0	54
Casuarina spp.	1	1	1	4	9	1	0	3	68	3	5	1	97
Xanthium spinosum	0	0	0	0	0	2	0	5	7	0	0	0	14
Artemisia spp.	0	0	0	0	0	0	0	0	0	0	1	1	2
Daphne gnidium	0	0	0	0	0	0	0	0	0	0	0	0	0
Hedera helix	0	0	0	0	0	0	0	0	0	0	0	0	0
Not identified	0	5	7	19	72	10	2	4	12	0	0	0	131
Total (daily concentrations sums)	520	1904	3115	6230	14433	3403	866	163	177	37	55	93	30996

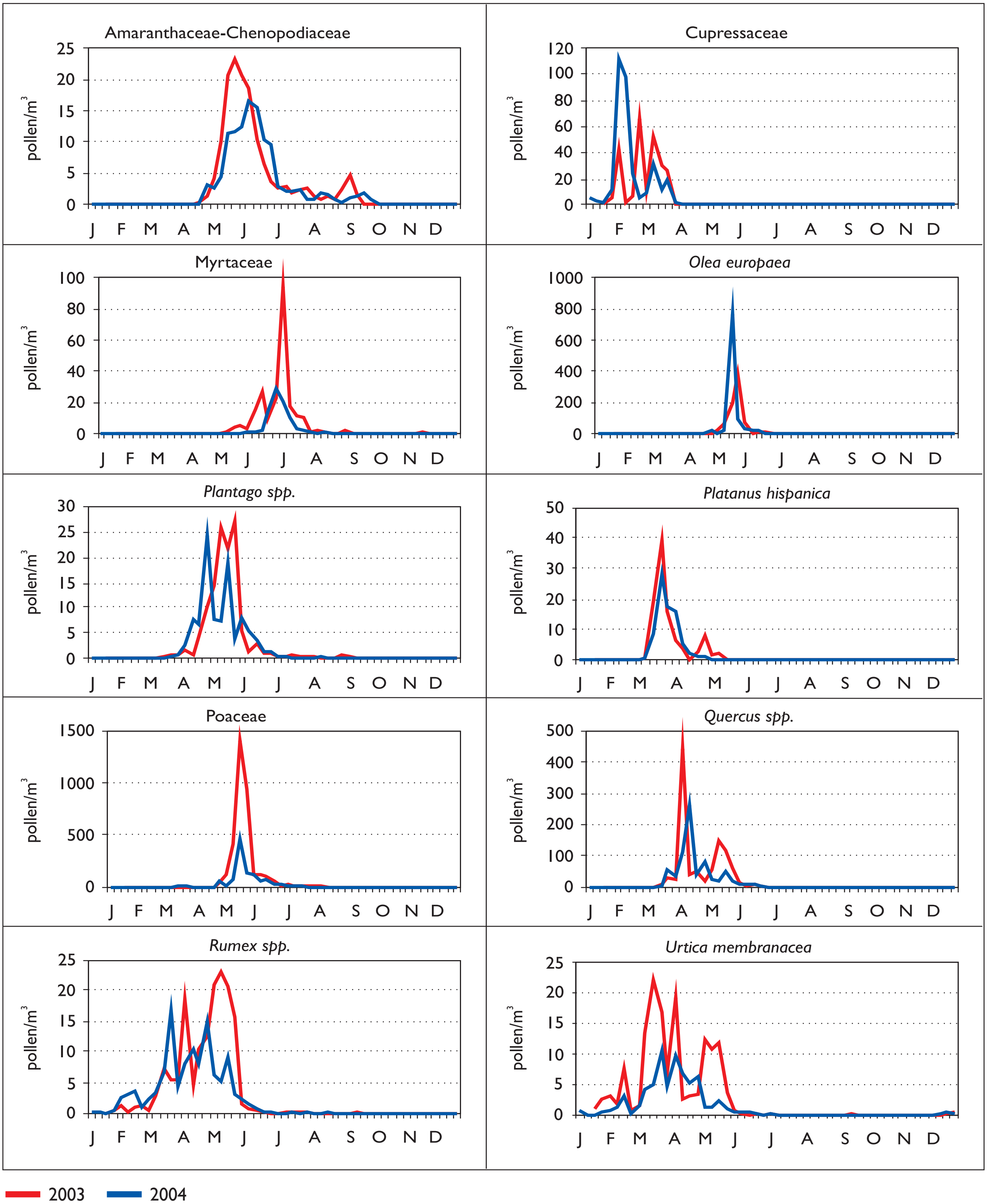

Figure 2. Weekly average pollen concentrations (pollen grains /m^3) for the main pollen types during 2003 and 2004

(Tables 1 and 2). The main pollen types were, in decreasing order, Poaceae, *Quercus* spp., *Olea europaea*, and Cupressaceae, representing 76.1% of the two-year total pollen counts. Most pollen types appeared in spring and the highest counts were obtained in May, April and June. The Cupressaceae, *Fraxinus* sp.-*Phillyrea* spp. *Parietaria* spp.-*Urtica* p.p., and *Urtica membranacea* pollen types showed a mainly winter pollination, and Amaranthaceae-Chenopodiaceae was a typical late spring-summer pollen type (Figure 2). Nine pollen types appeared at least on 100 days in one of the years studied, and only the Poaceae pollen type appeared on more than 200 days in both years (Table 3). The highest daily Poaceae pollen peak was observed on the 18th May 2003, with 2485 pollen grains/m^3, but in the second year their peak was the second in importance after the *Olea europaea* pollen type. The *Olea europaea* pollen type showed the second highest daily pollen

Table 3. Information about the main pollen types: number of days present, maximum daily pollen concentration, and day when the pollen peak appeared. Sampling from 20 January 2003 to 20 January 2005

Main pollen types	2003			2004		
	Days	Daily max	Date max	Days	Daily max	Date max
Amaranthaceae – Chenopodiaceae	148	49	31-may	154	25	11 and 16-jun
Anthemidae p. p.	55	10	28-may	52	5	04-may
Apiaceae	79	14	28-may	52	11	15-jun
Brassicaceae	41	8	16-mar	52	3	16-mar
Calendula sp. – *Helianthus* sp.	53	3	21-jun	40	9	12-jul
Celtis australis	60	28	08-apr	18	9	04-apr
Cupressaceae	113	327	24-feb	127	379	03-feb
Cyperaceae	51	6	21, 22 and 28-may	48	5	31-may
Echium spp.	75	15	22-may	63	10	24/4,14-15/5
Ericaceae	44	10	04-may	62	8	04-may
Fraxinus sp. – *Phillyrea* spp.	36	5	26-jan	72	36	02-jan
Lactuceae	85	19	27-may	76	11	31-may
Myrtaceae	104	121	03-jul	72	50	30-jun
Olea europaea	106	1339	22-may	85	1198	17-may
Parietaria spp. – *Urtica* p. p.	167	18	20-may	148	9	24-apr
Pinus spp.	121	78	02-apr	145	133	22-mar
Plantago spp.	106	30	09-may	104	55	24-apr
Platanus hispanica	52	94	16-mar	54	54	21-mar
Poaceae	228	2485	18-may	215	865	14-may
Quercus spp.	181	815	04-apr	173	800	09-apr
Rumex spp.	117	41	08-apr	137	48	21-mar
Urtica membranacea	118	54	20-mar	115	29	21-mar

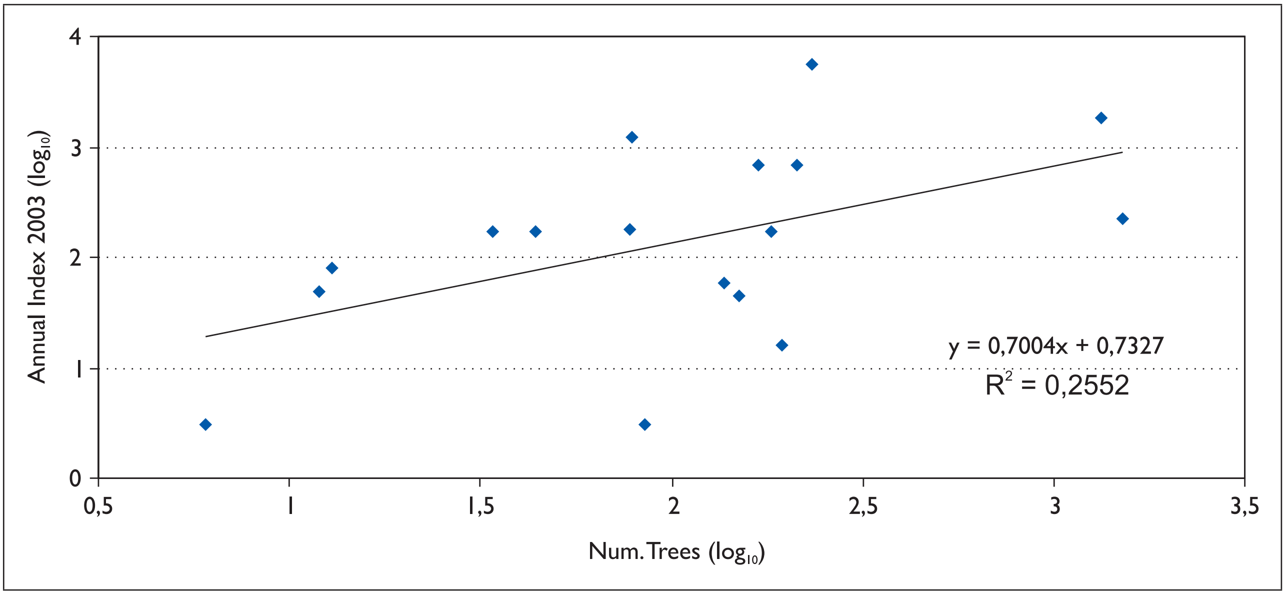

Figure 3. Regression analysis between the pollinic annual indices (sums of daily pollen concentrations) for ornamental plants exclusively and the numbers of ornamental trees using log transformed data

peak in 2003 and the highest in 2004, with 1339 (22nd May 2003) and 1198 (17th May 2004) pollen grains /m^3, respectively (Table 3). The peak of the *Quercus* spp. pollen type was third in importance and in both years was very similar in the amount and date on which it occurred (Table 3).

The Pearson correlation coefficient was statistically significant for the comparison between the number of ornamental trees and their annual indices for 2003 ($r = 0.505$, $p = 0.039$); nevertheless, for 2004 ($r = 0.360$, $p = 0.156$) and for the sum of the annual indices for 2003 and 2004 ($r = 0.456$, $p = 0.066$) there were no statistically significant correlations. Figure 3 shows data plotted, the straight line and the linear regression equation for 2003.

DISCUSSION

The overall annual indices for Beja were similar to those of nearby cities that have been studied aerobiologically – Badajoz[18,19,20], Merida[21,22], Seville[23,24] – although those studies correspond to previous years. Considering the 2003 data from Silva *et al.* in Badajoz[25] and Caeiro *et al.* in other places of Portugal[11], the annual index in Beja was higher than in Lisboa (36 392) and Portimão (30 285), but lower than Évora (68 792) and Badajoz (53 709). In Badajoz, the highest annual index per pollen type was for Poaceae (16 871), followed by *Quercus* spp. (10 887). While this was the same order as in Beja, the values were quite different. For 2004, the overall annual index for Beja was lower than for Lisboa (41 063), Évora (46 226), and Portimão (33 149). Whereas in Lisboa, the Urticaceae pollen type ranked first (34.8%), in Beja this pollen type represented less than 3%, probably due to the far less urban environment in Beja than in Lisboa. Compared with Évora, in Beja the Poaceae and Cupressaceae pollen types were far more important: in Évora they represent 26.2% (Poaceae) and 4.2% (Cupressaceae). In Portimão, the Olea pollen type is the most important (40.8%) while Poaceae only represents 15.2%, values that are very different from those found in Beja, nevertheless we cannot rule out the possibility of some pollen transport from these points.

The decline in pollen counts in the second year of the study was mainly caused by the decrease of Poaceae pollen type, whose annual index was 23 994 in 2003 and 8 083 in 2004. This difference was not offset by the increase in the indices of other main pollen types (Brassicaceae, Ericaceae, *Fraxinus* sp. – *Phillyrea* spp. *Pinus* spp., Cupressaceae, *Olea europaea*). A possible explanation for this reduction in Poaceae pollen was the pattern of rainfall. The higher rainfall in April 2003 could have favoured the growth of herbaceous plants that pollinated in May. This would have affected not only the Poaceae, but also other herbs in May, that also showed a significant reduction between 2003 and 2004, such as Amaranthaceae-Chenopodiaceae (-11.3%), Anthemideae p.p. (-28.8%), *Echium* spp. (-44.4%), Lactuceae (-37.8%), *Papaver rhoeas* (-57.7%), *Parietaria* spp.-*Urtica* p.p. (-40.6%), *Plantago* spp. (-16.2%), *Rumex* spp. (-25.6%), and *Urtica membranacea* (-52.8%). Hence, April rainfall could be a critical factor in determining the amount of herbaceous pollen present in the atmosphere, although it would be important to perform specific studies and analyse more years, to prove this assumption.

Many of the pollen types include not only ornamental trees but trees that grow naturally or are cultivated outside the town (*Fraxinus* sp.–*Phillyrea* spp., *Morus* spp., Myrtaceae, *Olea europaea*, *Pinus* spp., *Populus* spp., *Prunus* spp., *Salix babylonica*, *Ulmus minor*). Only the pollen types *Acacia* spp., *Acer negundo*, Arecaceae, *Casuarina* spp., *Celtis australis*, Cupressaceae, *Platanus hispanica*, and *Tilia* spp. comprise nothing but ornamentals, most of them restricted to the urban area. Although more years of study would probably be necessary, since we obtained statistically significant results in only one of the two years studied, it seems that there is a relationship between the number of ornamental trees and airborne pollen from these plants; this would be specially relevant with respect to allergy to Cupressaceae pollen, as it has been pointed out in other Mediterranean countries[26,27,28]. On average, each ornamental tree contributed with about 5 pollen grains (annual sum) to total pollen counts in the overall annual index, and the 17 pollen types considered in the correlation study represent 29.3% of the total amount of pollen, a figure similar to that obtained for Seville[29], while bearing in mind that not all the pollen of these types is of ornamental origin. Nevertheless, the allergenic importance of these pollen types is often underestimated[30,31] and there is an increasing trend in their relative contribution to the total pollen load[32]. We expect that this study may be useful for allergy professionals in Portugal, where pollens are one of the main aeroallergens responsible for respiratory allergic diseases[33,34].

CONCLUSIONS

The airborne pollen spectrum in Beja is typically Mediterranean, in particular very similar to other cities of the SW Iberian Peninsula, with the highest pollen concentrations corresponding to Poaceae, *Quercus* spp., and *Olea europaea*. Nearly 60% of airborne pollen appeared in May, followed by April (15.7%), June (8.1%) and March (7.1%), and in winter we registered less than 1% of the total airborne pollen. Pollen concentration in May has reached, on average, more than 1000 grains per cubic meter. However, more years of study would be necessary to obtain a more stable pollen calendar, mainly for immunoallergological purposes. The interannual differences observed between the two years of the study were probably due to the different spring rainfall patterns, which favoured the growth of herbaceous plants in the first year relative to the second, since, while the main pollination of these species occurs in May, their production depends to a major degree on April rains.

In 2003, some correlation was observed between the numbers of the different ornamental trees in the city and their pollen in the atmosphere. A particular case was the abundance of cypresses as ornamentals in the town and their pollen abundance, which was greater than in other nearby cities.

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