Science of the Total Environment 505 (2015) 1036–1042

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Aerobiological and phenological study of *Pistacia* in Córdoba city (Spain)

María José Velasco-Jiménez *, Manuel Arenas, Purificación Alcázar, Carmen Galán, Eugenio Domínguez-Vilches

Department of Botany, Ecology and Plant Physiology, University of Córdoba, Spain

HIGHLIGHTS

- *Pistacia* airborne pollen and flowering phenology have been studied in Córdoba city.
- pollen index increased and pollen season coincided with phenological observations.
- *Pistacia* pollen counts were sufficient to identify seasonal and diurnal patterns.
- This pollen type should be taken into account in pollen calendars.

ARTICLE INFO

Article history:
Received 11 July 2014
Received in revised form 6 October 2014
Accepted 6 October 2014
Available online xxxx

Editor: P. Kassomenos

Keywords:
Pistacia
Phenology
Airborne pollen

ABSTRACT

Pistacia species grow in temperate regions, and are widespread in the Mediterranean area. Two species can be found in the Iberian Peninsula: *Pistacia lentiscus* L. and *Pistacia terebinthus* L. Airborne pollen from these species, recorded in some Spanish provinces, is regarded by some authors as potentially allergenic, and therefore should be of particular interest, given that these species are actually being introduced as ornamentals in parks and gardens. This paper deals with a study of daily and seasonal *Pistacia* airborne pollen counts in Córdoba city, analysed in parallel with field flowering phenology data. The study was carried out in Córdoba, using a volumetric Hirst-type sampler in accordance with Spanish Aerobiology Network guidelines. Phenological monitoring was performed weekly from January to May at 7 sites in the mountain areas north of Córdoba city. The *Pistacia* pollen season lasted an average of 41 days, from mid-March to end of April. Higher pollen counts were recorded in evening hours. The pollen index increased over the study period, and the pollen season coincided with phenological observations. Some airborne pollen grains were recorded once flowering had finished, due to re-suspension or transport from other locations. *Pistacia* pollen counts in Córdoba were low, but sufficient to identify seasonal and daily patterns. This pollen type should be taken into account in pollen calendars, in order to fully inform potential allergy-sufferers. The number of trees introduced as ornamentals should be carefully controlled, since widespread planting could increase airborne pollen levels.

1. Introduction

Pistacia species grow in warm and temperate regions of the northern hemisphere, predominantly in the sclerophyllous scrublands of the Mediterranean Basin (Jordano, 1988). Two species are to be found in the Iberian Peninsula: *Pistacia lentiscus* L., which grows in all kinds of soil, and at altitudes ranging from sea level to over 1000 m, and *Pistacia terebinthus* L., which, though more common on rocky ground, may also grow in all soils from sea level up to 1500 m in more temperate regions (Valdés et al., 1987; Trigo et al., 2008). Both species grow throughout the mountain areas north of Córdoba, where the predominant scrub vegetation is characterised by perennial shrubs; the most abundant associations (Fig. 1) include Cistaceae, aromatic Lamiaceae, Anacardiaceae, Myrtaceae species as well as *Arbutus unedo* groves (Rivas-Martínez, 1987).

Since both species are dioecious, their breeding success is governed by the proportion of male to female trees in the population (Verdú and García-Fayos, 2002). Male flowers have 8–10 stamens, producing 47–60 × 10^3 pollen grains per flower, and are grouped in inflorescence of 8–10 flowers (Jordano, 1989). Pollen grains are tetraporate to polipantoporate, spheroidal, apolar and radiosymmetric, with a slightly reticulate surface (Trigo et al., 2008). Female flowers have unilocular tricarpellate ovaries with a single anatropous ovule (Verdú and García-Fayos, 2002). Flowering takes place between March and May, depending on altitude and climate, and there is some overlap in the flowering of males and females (Jordano, 1988; Correia and Díaz-Barradas, 2000; Martínez-Palle and Aronne, 2000; Verdú and García-Fayos, 2002). After pollination, ovaries remain latent for part of the summer. Subsequent rapid growth ends in the formation of fleshy

* Corresponding author at: Department of Botany, Ecology and Plant Physiology, Celestino Mutis Building, 3ª floor, Campus of Rabanales University of Córdoba, 14071 Córdoba, Spain. Tel.: +34 957218719.
E-mail address: bv2vejim@uco.es (M.J. Velasco-Jiménez).

http://dx.doi.org/10.1016/j.scitotenv.2014.10.017
0048-9697/

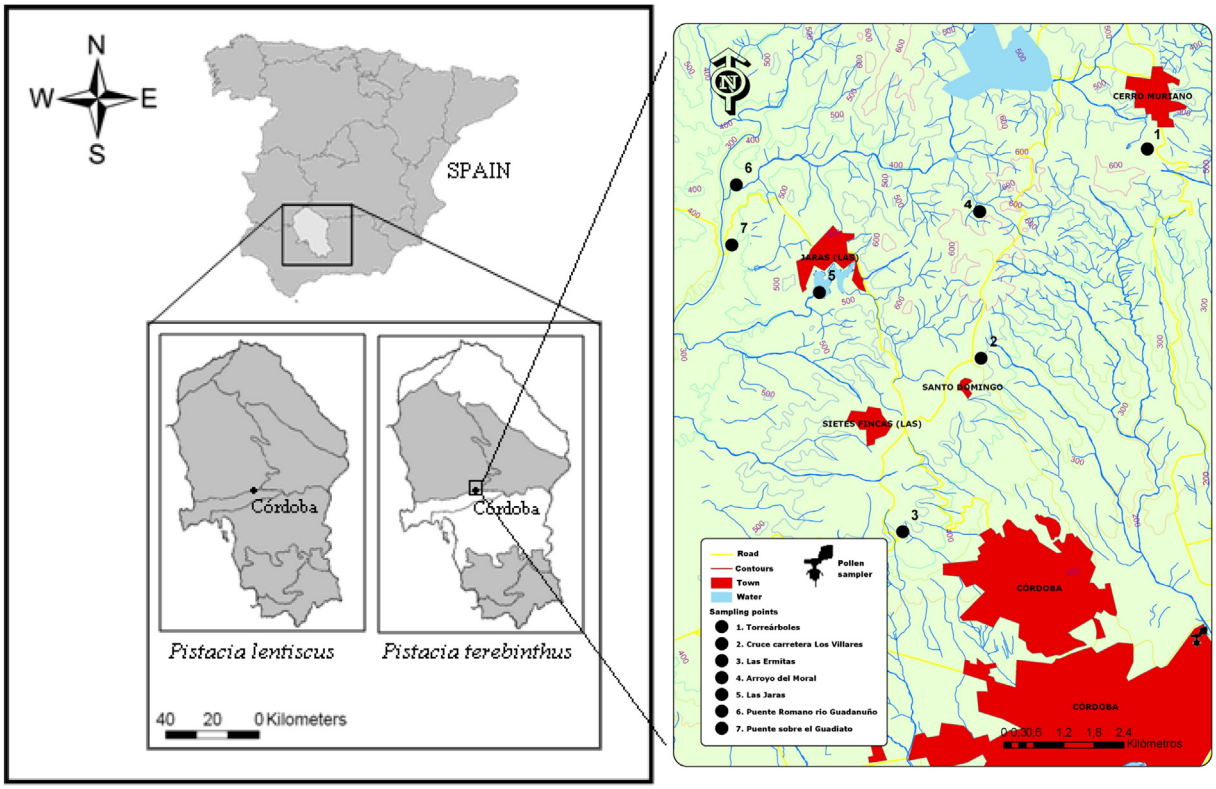

Fig. 1. Study area. Distribution of *P. lentiscus* L. y *P. terebinthus* L. in the province of Córdoba (Valdés et al., 1987) and location of the phenological monitoring sampling sites.

fruits with a single seed. Fruits are initially white; as they ripen, they turn reddish and eventually black (Verdú and García-Fayos, 2002).

This pollen type has been recorded in the air of some areas of Andalusia, Catalonia and Valencia (Trigo et al., 2008), and has been identified as allergenic by some authors, who report cross-reactivity with some *Schinus* species (Keynan et al., 1997; de Weerd et al., 2002). The potential allergenic impact of *Pistacia* species is of particular interest, especially since they are being introduced as ornamentals in urban parks and gardens in an attempt to increase public awareness of the value of natural flora (Staffolani et al., 2011; Velasco-Jiménez et al., 2014).

Recent research suggests that the Mediterranean area is becoming warmer due to climate change. This trend should influence the behaviour of *Pistacia* and other thermophilic species, lengthening their pollen season and modifying their distribution (Palacio et al., 2005) Giorgi and Lionello, 2008; Cecchi et al., 2010; García-Mozo et al., 2010, 2011).

Given the scarce information currently available, this study sought to chart daily and seasonal *Pistacia* airborne pollen counts in Córdoba city in conjunction with phenological flowering stages. It is hoped that the findings will provide sufficient information to fill the gaps in our knowledge of the aerobiology and phenology of these species.

2. Material and methods

The study was carried out in Córdoba (341642 X, 4192085 Y), a medium-sized city with a population of 329,618 (latest census, 2013); the city covers a surface area of 290.23 km^2 and is situated at 123 m above sea level. It has a Mediterranean climate with some continental features, characterised by cold, rainy winters and hot, dry summers. The mean annual temperature is 17.6 °C and means annual rainfall is 536 mm (1971–2000); prevailing winds (66%) are south-westerly (Instituto Nacional de Meteorología, 2001).

Aerobiological data were collected over the period 2009–2011 using a Hirst-type volumetric spore trap based on the impact principle (Hirst, 1952). The trap is located 22 m above ground level, on the roof of the Celestino Mutis Building at the Córdoba University Campus, roughly 8 km from the phenological sampling sites.

Samples were prepared and read following the guidelines laid down in the *Quality and Management Manual* published by the Spanish Aerobiology Network; hourly and daily mean pollen counts were expressed as pollen grains/m^3 of air (Galán et al., 2007).

The start date of the pollen season was defined as the first day on which ≥1 pollen grain/m^3 was recorded, with 5 subsequent days recording one or more pollen grains/m^3; the end date was the last day on which at least one pollen grain/m^3 was recorded and when no counts were recorded on 5 subsequent days. This definition of the pollen season was chosen since airborne *Pistacia* pollen count patterns are clearly-defined over time (Velasco-Jiménez et al., 2013).

Hourly data were recorded on rain-free days when pollen counts exceeded the daily mean for the main pollen period (Domínguez-Vilches et al., 1995).

Phenological monitoring of male flowers was carried out at 7 sampling sites containing both species, in the mountain areas, from now, Sierra de Córdoba, located at a representative range of altitudes and with a varying degree of exposure to sunlight (Fig. 1). Geographical features for each site are listed in Table 1.

For monitoring population phenology, ten individuals for each *Pistacia* species were selected in each sampling point to reflect optimal development and normal seasonality. Each individual was assigned an

Table 1
Features of the sampling points.

Sampling points	UTM X	UTM Y	Altitude (m)	Incline (%)
1. Torreárboles	344494	4206480	547	35
2. Los Villares	341168	4202339	531	55
3. Las Ermitas	339618	4198884	523	20
4. Arroyo del Moral	341168	4205590	505	14
5. Las Jaras	337967	4203634	447	0
6. Río Guadanuño	336316	4205768	310	44
7. Río Guadiato	336189	4204600	332	35

identification number. Field work consisted in weekly visits from January to May, in order to study the morphological changes taking place from budding to flower fall. For data collection purposes, the Extended BBCH Scale (Hack et al., 1992) was used. The scale was reduced to five stages (1 to 5) to facilitate the representation of results: Stage 1 (BBCH 51) — flower buds starting to swell, and separated by a small stalk; Stage 2 (BBCH 54) — inflorescence expanded, individual buds clearly visible, but still closed; Stage 3 (BBCH 61) — start of flowering (roughly 10% of flowers open); Stage 4 (BBCH 65) — full flowering (over 50% of flowers open); Stage 5 (BBCH 68) — flowers wilting (Fig. 2). Phenological development was recorded using a linear interpolation of weekly data, following Oteros et al. (2013). An individual was regarded as being at a given reproductive stage when at least 10% of the crown displayed the reproductive structures characteristic of that stage. The length of each stage in each study year and for each population was plotted on a bar chart.

3. Results

Table 2 shows meteorological and aerobiological data during the pollen season in the study years. Average temperature was lower during 2010 and higher in 2011, while rain was higher in 2010. Wind direction was from north-west in 2009 and 2011 and from south-west during 2010. In this year, wind speed was higher. About aerobiological data, the *Pistacia* species pollen season started in mid-March and ended in late April, lasting on average 41 days. The longest pollen season was recorded in 2009, when it started earlier and ended later than other years. In 2010, the season started one week later and ended almost a week earlier than the previous year, and was thus considerably shorter. In 2011, the pollen season started earlier than the previous year, closer to the 2009 start-date, but ended considerably sooner. The pollen peak date was earlier in 2009 than other years. The peak pollen count was much higher in 2011 almost twice that recorded for the two previous years; the annual pollen index was also higher. The contribution of *Pistacia* to total pollen counts for the season as a whole increased steadily over the three study years.

The seasonal behaviour of *Pistacia* pollen counts over the study period is shown in Fig. 3. Annual pollen curves differed from each other in terms of the time of peak pollen concentration; flowering intensity also displayed year-to-year variations. Several peaks were recorded over the pollen season, two peaks being particularly marked. These were recorded earlier in 2009, but occurred at similar times in the other two years. The highest peaks were observed in 2011.

Analysis of hourly changes is shown in Fig. 4. In this figure, 8 pollen grains represent 1%. The results showed that the highest *Pistacia* pollen counts were recorded in the evening, between 5 p.m. and 8 p.m., while the lowest were observed in the morning; counts declined from the early morning to reach minimum levels between 9 a.m. and 10 a.m.

Phenological stages for both *Pistacia* species at the various sampling sites, in conjunction with aerobiological data, over each study year are charted in Fig. 5. Preflowering phenophases (1–2) tended to last longer than flowering phenophases (3–4). This was particularly apparent at certain sites, where phenophase 3 was not recorded due to the short transition from phase 2 to phase 4, phase 3 proving impossible to detect during weekly monitoring. In general terms, flowering took place earlier at sites 2 and 3, and later at sites 6 and 7. Inter-species comparison showed that phase 1 lasted longer in *P. terebinthus* L. and subsequent phenophases were recorded earlier than in *P. lentiscus* L., with the result that flowering ended earlier.

4. Discussion

The *Pistacia* pollen season in the study area took place in March and April, as also reported by Jordano (1988) for Doñana, Moreno-Durán et al. (1997) for Cádiz, Montserrat-Martí and Pérez-Rontomé (2002) for north-eastern Spain and Verdú and García-Fayos (2002) for various sites in Portugal, Spain, Italy and Israel.

Annual differences in the content of *Pistacia* pollen in the air can be due to the meteorological characteristics of each year. Thus, low temperature and high rainfall occurred during the pollen season in 2010 may have caused the delay in the pollen season and the decrease in pollen concentration reached.

Both Jordano (1989) and Verdú and García-Fayos (2002) regard these *Pistacia* species as wind-pollinated, taking into account their flower structure and high pollen production. However, the present data showed that airborne pollen counts were considerably lower than

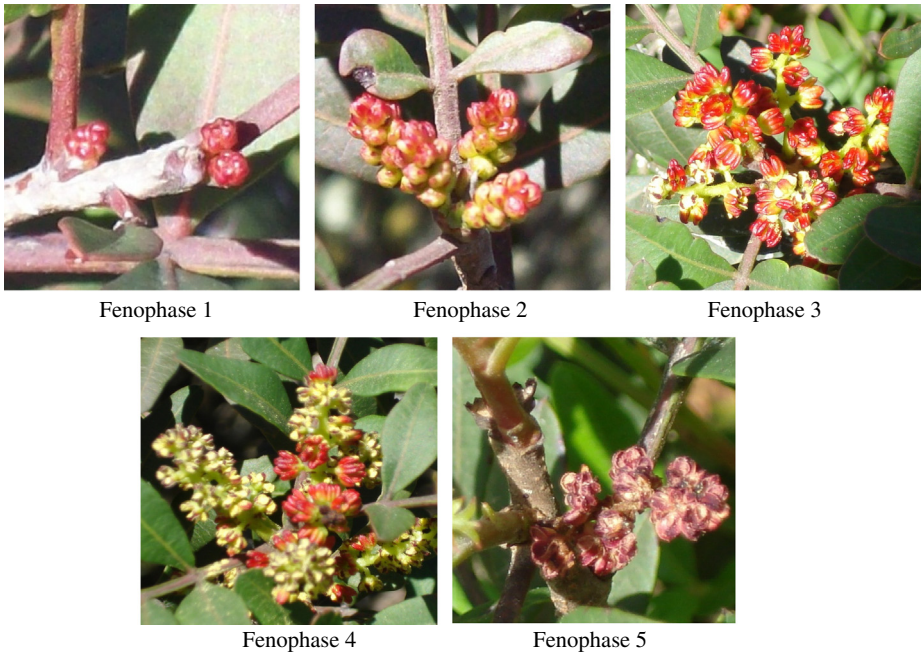

Fig. 2. Phenofases of the male flowers in *Pistacia lentiscus* L.

Table 2
Features of meteorological data and *Pistacia* pollen season for each year of study (2009–2011).

	Meteorological data during pollen season				Aerobiological data during pollen season						
	Average temperature (°C)	Accumulated rain (mm)	Wind speed (m/s)	Wind direction (°)	Start	End	N° days	Peak day	Concentration in the peak day (pollen grains/m^3)	Pollen index	% respect to the total
2009	15.8	60.1	1.69	151.1	76 (16-mar)	126 (5-may)	50	81 (21-mar)	48	477	1.29
2010	14.6	73.4	1.74	186.8	83 (23-mar)	120 (29-apr)	37	94 (3-apr)	38	299	1.79
2011	17.4	44.6	1.67	140.0	78 (18-mar)	113 (22-apr)	35	96 (5-apr)	107	764	2.02

those recorded for other wind-pollinated species growing in the same areas of the Sierra, such as *Quercus* and *Pinus*, for which concentrations in the season of 10,000 and 800 pollen grains/m^3, respectively, have been reported (Galán et al., 1991; García-Mozo et al., 2006). These low airborne pollen counts suggest a limited capacity for pollen-grain dispersal (Trigo et al., 2008). Furthermore, wind may also influence in the pollen count reached by the sampler. In 2010, the predominance wind direction was southwest and populations of *Pistacia* are located in the north-west of Córdoba city. This could also provoke the low concentrations of pollen grains detected this year. Anyway, if it is found to be allergenic, this pollen type should be taken into account when producing pollen calendars for potential allergy-sufferers. Similarly, number of trees introduced in future as ornamentals should be carefully controlled, since widespread planting could increase airborne pollen levels.

Analysis of diurnal variations showed that the highest *Pistacia* pollen counts were recorded in the evening. By contrast, other studies (Alcázar et al., 1999; Galán et al., 2000; Recio et al., 2002) report an increase in counts for other pollen types at midday, noting that the increase in air temperature accelerates pollen release and favours transport. *Pistacia* pollen, released in mountain areas close by, may be transported to the city on the mountain-valley winds flows, a finding also reported for *Quercus* by Galán et al. (1991).

Analysis of phenological data showed that flowering in both species took place earlier at the sunnier and open sites, as is the case of Los Villares and Las Ermitas. Flowering lasted longest in the most northerly sites (6 and 7), whose proximity to watercourses ensures a supply of water over a longer period. No significant differences in the timing of flowering were observed as a function of altitude, although research in other species suggests that flowering tends to take place later in populations at higher altitudes (Fornaciari et al., 2000; García-Mozo et al., 2006, 2009; Gómez-Casero et al., 2007; Oteros et al., 2013). The preflowering phase (swelling and separation of buds) lasted longer in *P. terebinthus* L., while subsequent phenophases were recorded earlier than in *P. lentiscus* L., with the result that flowering occur earlier. Ceballos et al. (1971); Castro-Díez and Monserrat-Martí (1998) report that *P. terebinthus* L. is more resistant to cold, and thus needs to accumulate more heat in order to break dormancy, leading to a longer preflowering stage. This was observed in 2011, which had higher temperatures, and *P. terebinthus* L. flowering was earlier regarding *P. lentiscus* L. Thereafter, however, flower development was faster than in the case of *P. lentiscus* L., where flowering phenophases took place earlier. The fact that in some study years and in some sampling points may have not observed phenophase 3 suggests to us that futures studies should increase the frequency of field visits at least 2 times per week in full flowering in order to collect this information.

Comparing the phenological phases with aerobiological data shows that the different peaks in the curve are related with the flowering in different sampling points. It seems that *P. lentiscus* L. contributes better to the pollen curve because peaks of this curve often coincide with the flowering period of this specie. This was particularly observed in 2010 when the gap between the flowerings of both species was greater.

Given the clear relation between pollen release and flowering phenology, the joint use of aerobiological and phenological methods provides an efficient research tool (Jato et al., 2002; León-Ruiz et al., 2011). A number of studies report a positive correlation between the development of reproductive structures and airborne pollen counts for various tree species, including Quercus (Gómez-Casero et al., 2007), Ulmus and Fraxinus (Latorre and Bianchi, 1998), Betula (Jato et al., 2002, 2007), Alnus, Betula and Corylus (Kasprzyk, 2003) and Cupressus (Hidalgo et al., 2003). Phenological observations have also been used to confirm the real contribution of olive pollen (Orlandi et al., 2005;

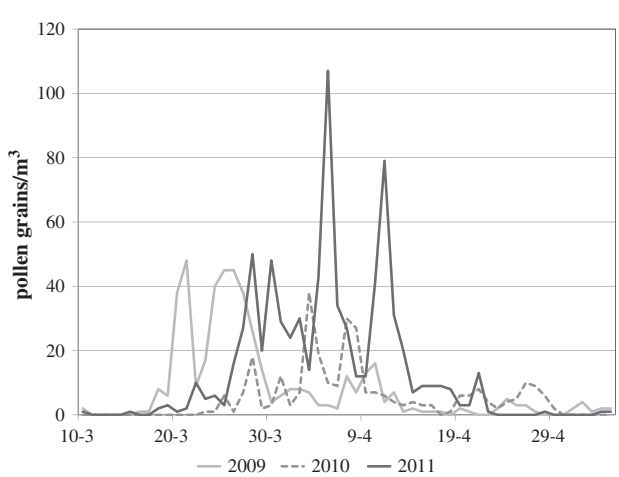

Fig. 3. Daily concentration of *Pistacia* pollen grains in the air during the pollen season in the study years.

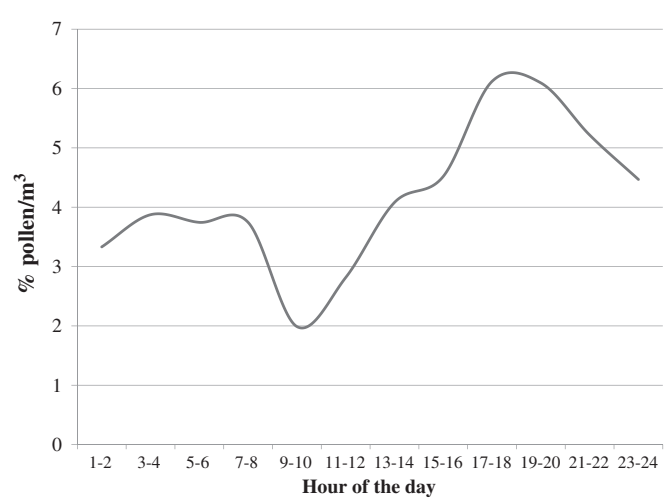

Fig. 4. Intraday variation of *Pistacia* pollen type (Spanish official time).

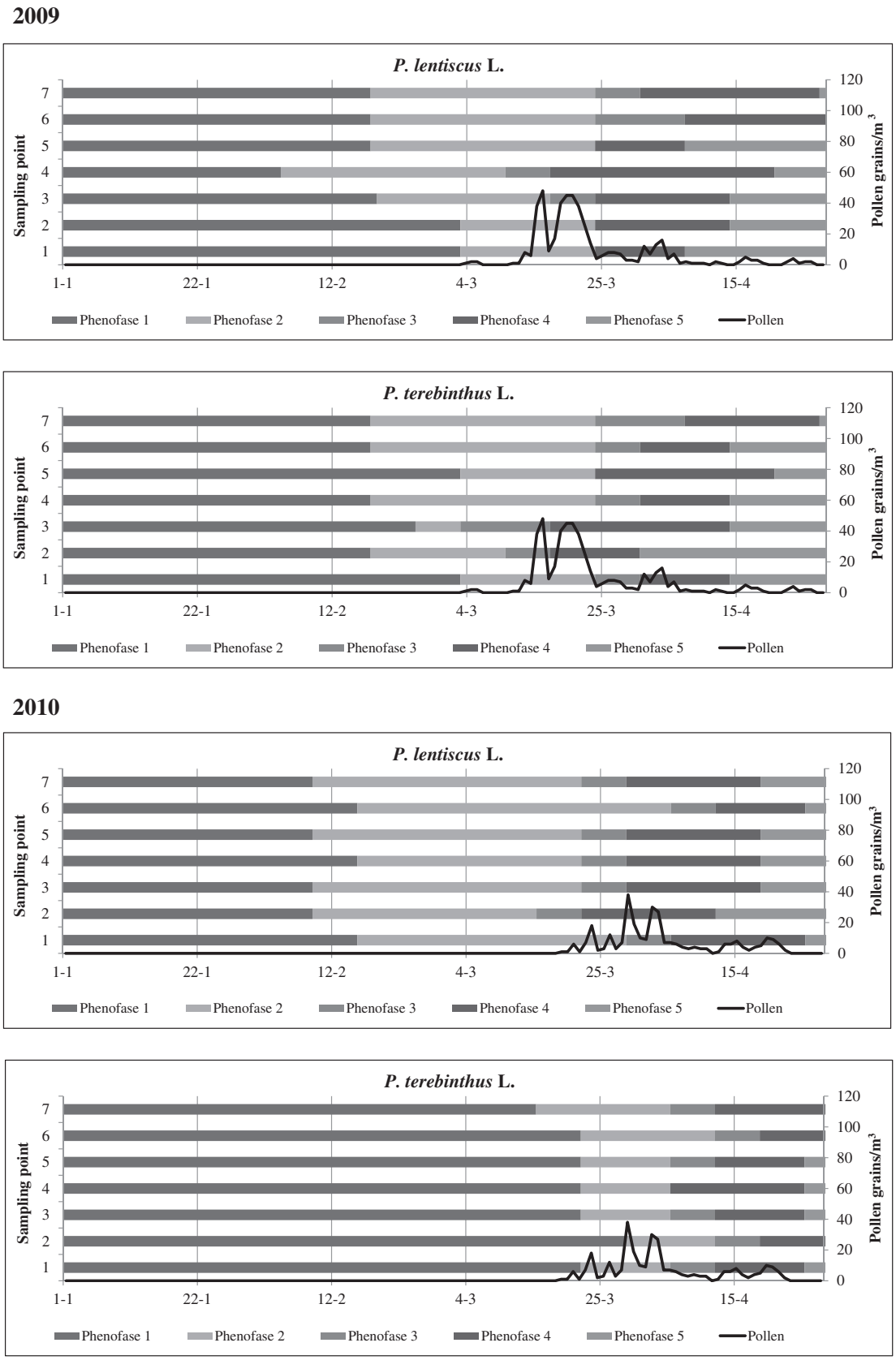

Fig. 5. Daily pollen concentrations vs. phenological phases in both species in each sampling point during the three years of study.

García-Mozo et al., 2006) and grass pollens (León-Ruiz et al., 2011) to the overall pollen curve. Here, the timing of flowering phenophases matched the timing of the main pollen season. Although, futures studies should increase the sampling points and the number of individuals in order to represent more communities of *Pistacia* and explain better the origin of the pollen.

2011

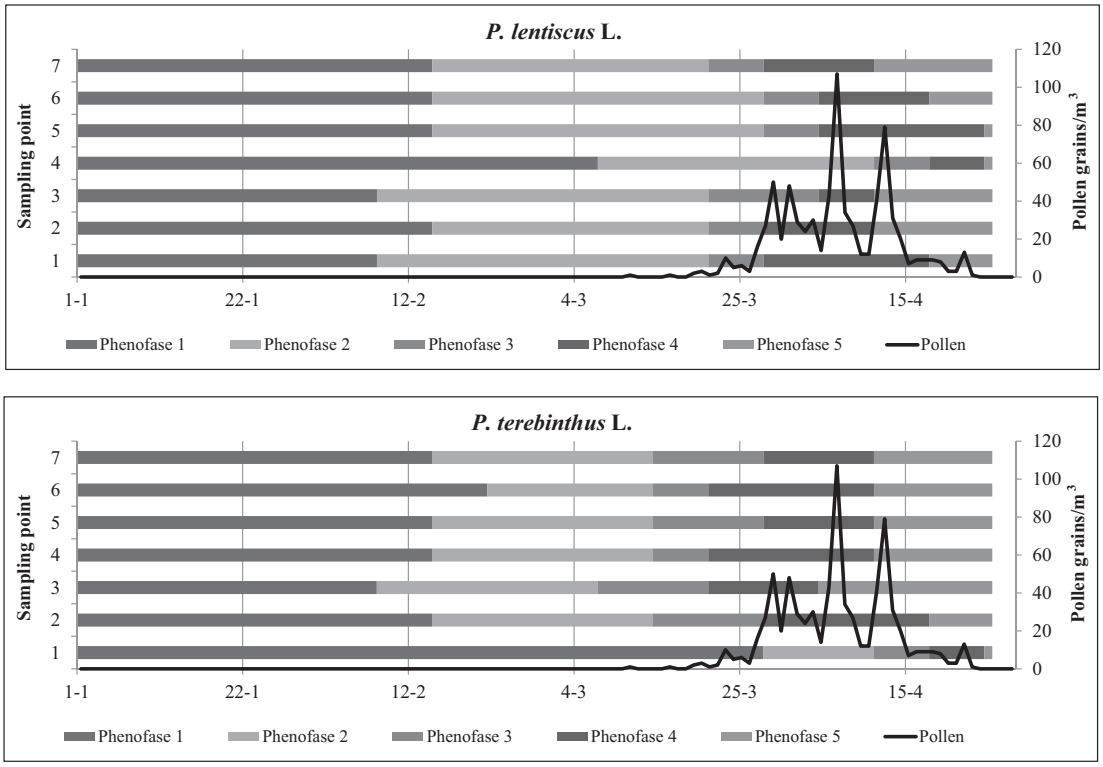

Fig. 5 (*continued*).

5. Conclusions

It has been observed a clear relation between field flowering phenology of *Pistacia* and airborne pollen in the study area. *P. lentiscus* L. contributes better to the pollen curve, coinciding the peaks of this curve with the flowering period of this species. This pollen type should be taken into account when producing pollen calendars for potential allergy-sufferers. Similarly, number of trees introduced in future as ornamentals should be carefully controlled, since widespread planting could increase airborne pollen levels.

Acknowledgements

Part of this study was supported by the project "RNM-5958: Análisis de la dinámica del polen atmosférico en Andalucía". Consejería de economía, innovación, ciencia y empleo, Secretaría General de Universidades, Investigación y Tecnología, Junta de Andalucía.

References

Alcázar P, Galán C, Cariñanos P, Domínguez-Vilches E. Diurnal variations of airborne pollen at two different heights. J Investig Allergol Clin Immunol 1999;9(2):89–95.
Castro-Díez P, Monserrat-Martí G. Phenological pattern of fifteen Mediterranean phanaerophytes from shape Quercus ilex communities of NE-Spain. Plant Ecol 1998;139(1):103–12.
Ceballos L, de Córdoba F, de la Torre, JR. Árboles y arbustos de la España peninsular. Escuela Técnica Superior de Ingenieros de Montes. Sección de Publicaciones; 1971.
Cecchi L, D'Amato G, Ayres JG, Galan C, Forastiere F, Forsberg B, et al. Projections of the effects of climate change on allergic asthma: the contribution of aerobiology. Allergy 2010;65:1073–81.
Correia O, Díaz-Barradas MC. Ecophysiological differences between male and female plants of *Pistacia lentiscus* L. Plant Ecol 2000;149:131–42.
de Weerd NA, Bhalla PL, Singh MB. Aeroallergens and pollinosis: molecular and immunological characteristics of cloned pollen allergens. Aerobiologia 2002;18(2):87–106.
Domínguez-Vilches E, Cariñanos P, Soldevilla CG, Pasadas FG, García-Pantaleón FI, de la Torre FV. Airborne pollen concentrations, solid particle content in the air and allergy symptoms in Córdoba (Spain). Aerobiologia 1995;11(2):129–35.
Fornaciari M, Galán C, Mediavilla A, Domínguez-Vilches E, Romano B. Aeropalynological and phenological study in tow different Mediterranean olive areas: Cordoba (Spain) and Perugia (Itlay). Plant Biosyst 2000;134(2):199–204.
Galán C, Tormo R, Cuevas J, Infante F, Domínguez-Vilches E. Theoretical daily variation patterns of airborne pollen in the south west of Spain. Grana 1991;30:201–9.
Galán C, Alcázar P, Cariñanos P, García-Mozo H, Domínguez-Vilches E. Meteorological factors affecting daily urticaceae pollen count in southwest Spain. Int J Biometeorol 2000;43:191–5.
Galán C, Cariñanos P, Alcázar P, Domínguez-Vilches E. Manual de Calidad y Gestión de la Red Española de Aerobiología. Servicio de Publicaciones. Universidad de Córdoba; 2007.
García-Mozo H, Galán C, Vázquez L. The reliability of geoestatistic interpolation in olive field floral phenology. Aerobiologia 2006;22:97–108.
García-Mozo H, Galán C, Belmonte J, Bermejo D, Candau P, Díaz de la Guarda C, et al. Predicting the start and peakdates of the Poaceae pollen season in Spain using process-based models. Agr Forest Meteorol 2009;149(2):256–62.
García-Mozo H, Mestre A, Galán C. Phenological trends in southern Spain: a response to climate change. Agr Forest Meteorol 2010;150(4):575–80.
García-Mozo H, Mestre A, Galan C. Climate change in Spain: phenological trends in southern areas. In: Blanco Juan, Kheradmand Houshang, editors. Climate Change Socioeconomic Effects. Editorial: InTech 978-953-307-411-5; 2011. p. 237–50.
Giorgi F, Lionello P. Climate change projections for the Mediterranean region. Global Planet Change 2008;63:90–104.
Gómez-Casero MT, Galán C, Domínguez-Vilches E. Flowering phenology of mediterranean Quercus species in different locations (Córdoba, SW Iberian Peninsula). Acta Bot Malacit 2007;32:127–46.
Hack H, Bleiholder H, Buhr L, Meier U, Schnock-Fricke U, Weber E, et al. Einheitliche Codierung der phanologischen Entwicklungsstadien mono-und dikotyler pflanzen – Erweiterte BBCH-Skala, Allgemein. Nachrbl Dtsch Pflanzenschutzd 1992;44:265–70.
Hidalgo PJ, Galán C, Domínguez E. Male phenology of three species of Cupressus: correlation with airborne pollen. Trees 2003;17:336–44.
Hirst JM. An automatic volumetric spore-trap. Ann Appl Biol 1952;36:257–65.
Instituto Nacional de Meteorología. Guía resumida del clima de España 1971–2000. Madrid: Centro de publicaciones. Secretaría General Técnica Ministerio de Medio Ambiente; 2001.
Jato V, Méndez J, Rodríguez-Rajo J, Seijo MC. The relationship between the flowering phenophase and airborne pollen of Betula in Galicia (NW Spain). Aerobiologia 2002;18:55–64.
Jato V, Rodríguez-Rajo FJ, Aira MJ. Use of *Quercus ilex* subsp. ballota phenological and pollen-production data for interpreting *Quercus* pollen curves. Aerobiologia 2007; 23(2):91–105.

Jordano P. Polinización y variabilidad de la producción de semillas en *Pistacia lentiscus* L. (Anacardiaceae). Anales Jará Bot Madrid 1988;45(1):213–31.
Jordano P. Pre-dispersal biology of *Pistacia lentiscus* (Anacardiaceae): cumulative effects on seed removal by birds. OIKOS 1989;55:375–86.
Kasprzyk I. Flowering phenology and airborne pollen grains of chosen tree taxa in Rzeszów, SE Poland. Aerobiologia 2003;19:113–20. [Ketres editora S.A. Barcelona (Spain)].
Keynan N, Tamir R, Waisel Y, Reshef A, Spitz E, Shomer-Ilan A, et al. Allergenicity of the pollen of *Pistacia*. Allergy 1997;52:323–30.
Latorre F, Bianchi MM. Relationships betwen flowering development of *Ulmus plumila* and *Fraxinus excelsior* and their airbone pollen. Grana 1998;37:233–8.
León-Ruiz E, Alcázar P, Domínguez-Vilches E, Galán C. Study of Poaceae phenology in a Mediterranean climate. Which species contribute most to airborne pollen counts? Aerobiologia 2011;27(1):37–50.
Martínez-Palle E, Aronne G. Reproductive cycle of *Pistacia lentiscus* (Anacardiaceae) in southern Italy. Plant Biosyst 2000;134:365–71.
Montserrat-Martí G, Pérez-Rontomé C. Fruit growth dynamics and their effects on the phenological pattern of native Pistacia populations in NE Spain. Flora 2002;197(3): 161–74.
Moreno-Durán MD, Ortega JM, Rodríguez de los Santos M. Datos fenológicos de floración de algunas especies leñosas de la Duna del Faro de Trafalgar (Barbate, Cádiz). Acta Bot Malacit 1997;22:43–52.
Orlandi F, Ruga L, Romano B, Fornaciari M. An integrated use of aerobiological and phenological data to analyse flowering in olive groves. Grana 2005;44:51–6.
Oteros J, García-Mozo H, Vázquez L, Mestre A, Domínguez-Vilches E, Galán C. Modelling olive phenological response to weather and topography. Agr Ecosyst Environ 2013; 179:62–8.
Palacio S, Milla R, Montserrat-Martí G. A phenological hypothesis on the thermophilous distribution of *Pistacia lentiscus* L. Flora 2005;200(6):527–34.
Recio M, Trigo MM, Docampo S, Cabezudo B. Estudio del ritmo intradiario del polen total en la atmósfera de Málaga durante los años 1992–1997. Rea 2002;7:17–22.
Rivas-Martínez, S. (1987). *Memoria del mapa de series de vegetación de España 1:400.000*. ICONA. Madrid. 268 pp.
Staffolani L, Velasco-Jiménez MJ, Galán C, Hruska K. Allergenicity of the ornamental urban flora: ecological and aerobiological analyses in Córdoba (Spain) and Ascoli Piceno (Italy). Aerobiologia 2011;27:239–46.
Trigo MM, Jato V, Fernández D, Galán C. Atlas aeropalinológico de España. Secretariado de Publicaciones. Universidad de León; 2008.
Valdés B, Talavera S, Fernández-Galiano E. Flora vascular de Andalucía occidental, Volumen I-II-IIIS.A. Barcelona. : Ketres editora; 1987.
Velasco-Jiménez MJ, Alcázar P, Domínguez-Vilche SE, Galán C. Comparative study of airborne pollen counts located in different areas of the city of Córdoba (south-western Spain). Aerobiologia 2013;29:113–20.
Velasco-Jiménez MJ, Alcázar P, Valle A, Trigo MM, Minero F, Domínguez-Vilches E, et al. Aerobiological and ecological study of the potentially allergenic ornamental plants in south Spain. Aerobiologia 2014;31:91–101.
Verdú M, García-Fayos P. Ecología reproductiva de *Pistacia lentiscus* L. (Anacardiaceae): un anacronismo evolutivo en el matorral mediterráneo. Rev Chil Hist Nat 2002;75.