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Original article

Privet pollen (*Ligustrum* sp.) as potential cause of pollinosis in the city of Cordoba, south-west Spain

Background: Privet pollen rarely accounts for more than 1% of the annual total of daily pollen concentrations measured in a city; however in areas where these trees are widely used as ornamentals the amounts collected may be high enough to cause allergy symptoms.
Methods: Air samples taken with volumetric particle samplers Lanzoni VPPS 1000 (Lanzoni s.r.l., Bologna, Italy) show that there are differences in privet pollen concentrations measured in neighbourhoods with a high incidence of privet trees and in those taken at some distance from the source of emission.
Results: The results suggest that differences are due to the short dispersal range of the pollen grains once released from the plant, resulting from both the entomophilous nature of the plant and the large size of the pollen grains. Urban design, moreover, may play an important role in impeding pollen grain dispersion if the air cannot flow freely through long, narrow avenues. Another important consideration is that the last stages of the flowering period of privet overlaps with the flowering period of olive trees, the main allergen in the area. The fact that the two pollen types share common allergens means that there may be a cross-reaction between olive tree pollen and privet pollen.
Conclusions: Privet pollen should be considered as a potential causative agent of local allergy problems in areas where its presence is extensive and is in combination with other allergens.

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Key words: biological pollution; *Ligustrum* pollen; Oleaceae allergy; privet; urban allergy.

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The genus *Ligustrum* (privet) is part of the Oleaceae family and comprises about 20 species, subspecies and varieties. Of these, seven species are endemic to India (1), while the others grow naturally across Europe in narrow passes and mountains above 1000 m (2); however, they are most frequently found in urban environments, since they are widely used as either ornamental trees or hedges in parks and gardens. In Spain three species are used most widely in gardening: *Ligustrum japonicum, L. ovalifolium* and *L. lucidum,* the latter due to its reluctance to adapt to urban conditions and tolerance of cutting and pruning.

They are usually found as small trees or shrubs but some specimens can reach a height of 10 m; they are deciduous or evergreen with entire, coriaceous, lanceolate or oval-shaped leaves. They contain a large amount of oleuropein, a phenolic secoiridoid glycoside (3). The small, white flowers are grouped in terminal clusters that bloom spectacularly. Flowering takes place during late-May, June and July, and pollination is entomophilous. This latter characteristic, together with the large size of its pollen grains (4), impedes long-distance dispersion of the pollen. As in other Oleaceae species, such as *Syringa*, *Fraxinus, Jasminum* and *Forsithya*, privet pollen grains contain the allergen Ole e 1. This is considered to be the chief allergen of Oleaceae (5–7) and its occurrence across the species favours cross-reactivity amongst them.

According to pollen records of the last eight years from a permanent particle sampler operated in the city of Cordoba, south-west Spain, privet pollen can be detected in air samples during May, June and July in quantities that rarely exceed the daily average of 15–20 grains/m^3 of air, accounting for less than 1% of the annual pollen spectrum of the city (8–10). Although no threshold levels have been established for this pollen type, findings in closely related species report the number of 400 grains/m^3/day as the concentration needed to produce symptoms in monosensitized *Olea* pollen allergic patients (11). However, an increasing number of calls to our Pollen Information line from people suffering from olive pollen allergy, when airborne olive pollen concentrations were decreasing, made us study these cases in more detail. Most complaints came from residents of a neighbourhood in the Eastern District of the city, where privets are used profusely as ornamentals. The first thought was that the privet pollen concentrations recorded in the vicinity of the source of emission might differ from those detected by a sampler placed at a certain distance, and high enough to cause symptoms. If differences were found the pattern of dispersion of pollen grains from their source of origin could be studied.

Material and methods

Measurements of airborne pollen concentrations were taken in the city of Cordoba (4°45′W, 37°50′N) in the south-west of the Iberian Peninsula. Many plant species flower almost throughout the whole year because of this area's Mediterranean weather. The pollen spectrum obtained with the permanent Hirst-type sampler working in the city not only represents the species most commonly found there, but also gives a general picture of the surrounding natural flora (8–10).

Species of *Ligustrum* are widely used as urban ornamentals and together with *Platanus* and *Cupressus* are among the most abundant species. According to official data from the City Council Parks and Gardens Department, there were a total of 2346 privet trees in the city in 1998. Their distribution around the city is irregular; the highest concentration is in the Eastern District where they frequently line roadsides.

As well as the airborne samples obtained from the permanent 15 m sampler located in the Western District, at the Faculty of Science building, local measurements were taken during the period 1–7 June 2000, with portable Lanzoni VPPS 1000 (Lanzoni s.r.l., Bologna, Italy) samplers at several points along the Avenida Virgen de Fatima, a 1200 m long avenue with four-storey buildings on either side and situated 5 km further east than the permanent sampler. The 152 privet trees in this neighbourhood represented the highest concentration in the city, accounting for 6.47% of the total. These trees are situated along sidewalks beside the main road. Samples were obtained by placing the portable samplers at human head height for 30 consecutive minutes in different parts of the Avenue, during the period of maximum pollination. To facilitate comparison of the results obtained with the different samplers only untransformed data were considered (the number of pollen grains found in the samples without being transformed into pollen grains/m3 of air) during sampling. Samples were also taken in an open area at the Rabanales University Campus, a further 5 km east on the outskirts of the city, where there are many privet trees in an isolated area. This enabled us to study pollen dispersion in an open, unobstructed space.

The scenarios selected are given below.

1 Samples were taken over three consecutive days from:

- Portable 1 (A) placed at a street intersection at the beginning of the privet-line in Avenue Virgen de Fatima at a height of 1.5 m.
- Portable 2 (B) placed in the middle of the privet line in Avenue Virgen de Fatima, 500 m away from A, at a height of 1.5 m.
- Permanent device (C) placed at the Faculty of Sciences building, Western District, 5 km west of A and B, at a height of 15 m.

2 Two-day samples were obtained from:

- Portable 1 (A) placed in the middle of the privet line at a height of 1.5 m.
- Portable 2 placed in an avenue parallel to the previous one, at a distance of 100 m down a smooth hill, with a barrier of four- and five-storey buildings in between, at a height of 1.5 m.
- Permanent device (C) in the same place as in scenario 1.

3 Two-day samples were obtained from:

- Portable 1 (A) placed in the outskirts of the city, at the Rabanales University Campus at a height of 1.5 m.
- Portable 2 (B) placed 25 m away from (A), in an open area, without any obstruction impeding airflow at a height of 1.5 m.
- Permanent device (C): in the same place as in scenario 1

The daily concentrations and the annual totals of privet pollen collected with the permanent sampler over the last eight years are presented in Figs 1 and 2 in order to show the distribution of this pollen type in the atmosphere of the city. Mean daily distribution of airborne olive and privet pollen in Cordoba from the beginning of April to the end of July are also presented (Fig. 3) in order to compare the pattern of distribution for both pollen types. Data are for daily averages from 1993 to 2000.

Table 1. Three-day results obtained in scenario 1

Sampler	Day 1	Day 2	Day 3
A	26	87	28
B	38	113	98
C	4	1	1

A & B: Avenue Virgen de Fatima (1.5 m height); C: Western District (15 m height).

Table 2. Two-day results obtained in scenario 2

Sampler	Day 1	Day 2
A	31	58
B	5	20
C	0	2

A & B: Avenue Virgen de Fatima (1.5 m height); C: Western District (15 m height).

Results

Figure 1 shows privet pollen concentrations measured in the atmosphere of Cordoba over the last eight years by a permanent pollen sampler placed at the Faculty of Sciences building in the Western District. The concentrations rarely exceeded the daily value of 15–20 grains/m^3 of air, although figures above 50 grains/m^3 were noted over several days in 1997 and 1998. For each year, depending on the pattern of rainfall distribution, the seasonal peak may occur in late-May, June or even July. The daily values tend to be low and homogeneous, but peaks do occur frequently and reliably. The annual sum of the daily average concentrations (Pollen Index) can be as low as only 38, as was the case in 1995, or close to 300, as occurred in 1996 (Fig. 2).

Table 1 shows the results obtained from three-day sampling in scenario 1. It is evident that local concentrations, those obtained in A and B at a height of 1.5 m, are significantly higher than those taken at some distance (C). It can be also seen that higher pollen values are obtained closer to the source of emission (B).

Values obtained in scenario 2 (Table 2) confirmed that high quantities of privet pollen were again recorded

Table 3. Two-day results obtained in scenario 3

Sampler	Day 1	Day 2
A	45	61
B	17	63
C	1	2

A & B: University Campus (1.5 m height); C: Western District (15 m height).

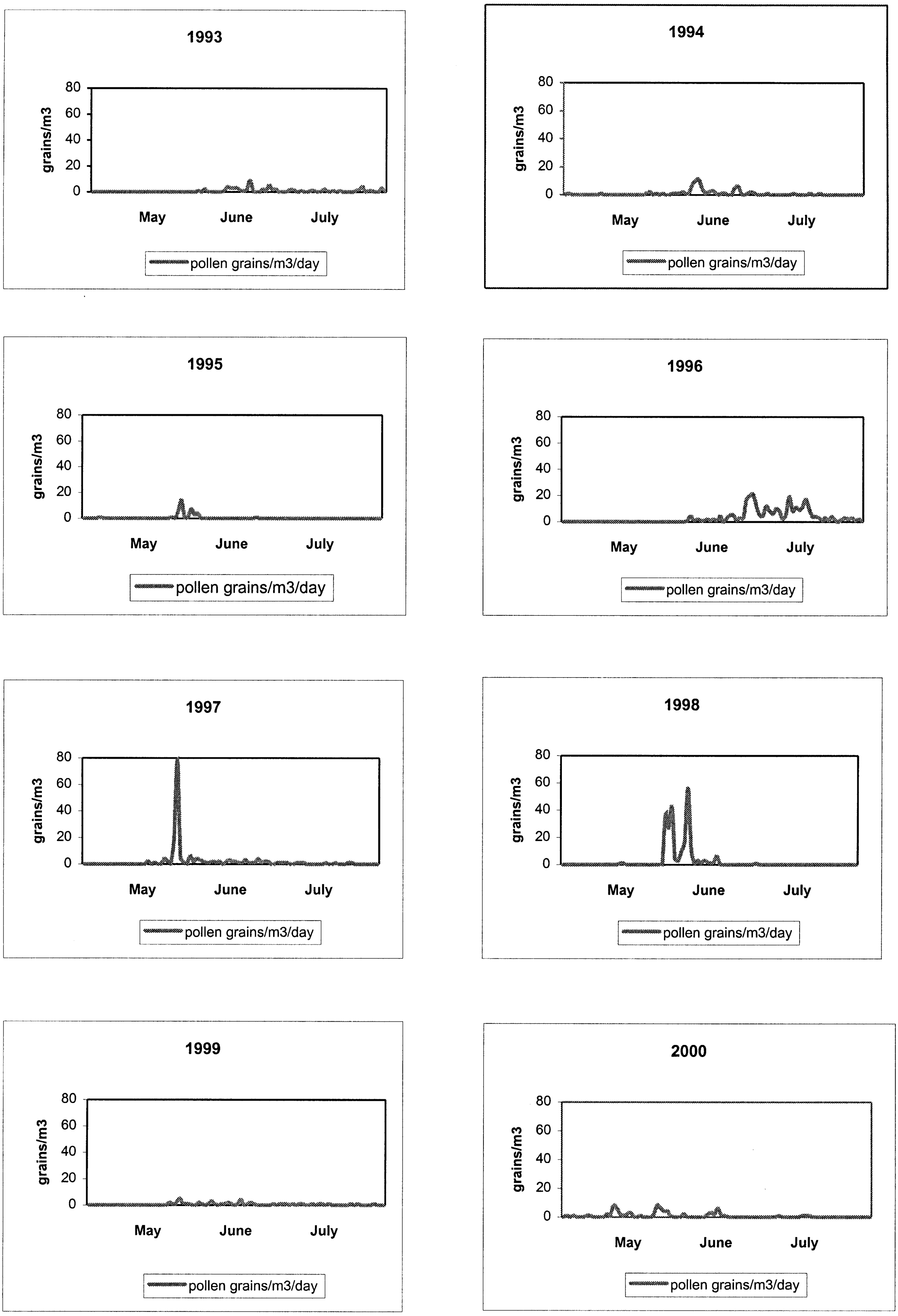

Figure 1. Daily distribution of *Ligustrum* (privet) pollen recorded in the atmosphere of Cordoba during May, June and July of 1993–2000.

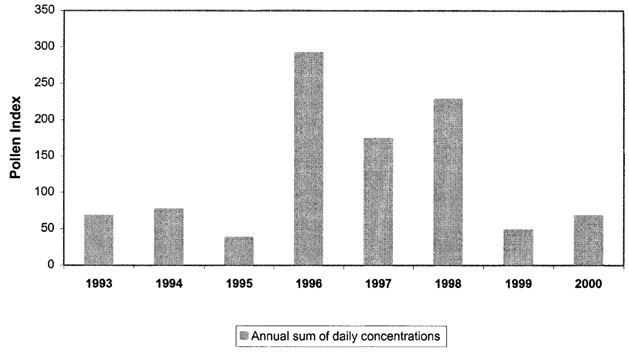

Figure 2. Annual sum of the daily average concentrations of *Ligustrum* (privet) pollen recorded in the atmosphere of Cordoba from 1993 to 2000.

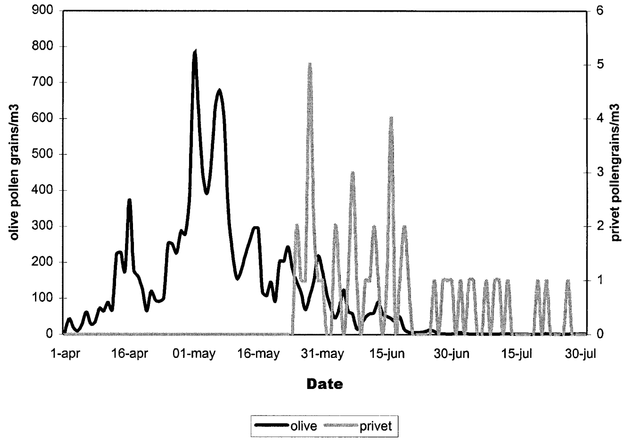

Figure 3. Average daily distribution of *Olea* (olive) pollen and *Ligustrum* (privet) pollen recorded in the atmosphere of Cordoba from 1st April to 30th June over the last eight years.

in the sampler placed close to the source of emission, that is the one placed in the middle of the privet line (A). However, the amounts of pollen recorded with sampler B, placed only 100 m away from A but separated by a barrier of four- and five-storey buildings, were comparatively lower. Again in both cases there is a considerable difference from pollen concentrations detected by the permanent sampler (C).

Amounts of pollen greater than those at the site of the permanent sampler in the Western District (C) can be collected in a sampler placed at some distance from the source at a height of 1.5 m, provided there is no obstacle impeding free air flow (Table 3). The wind direction seems to have some bearing on the results: during the first day a leeward direction caused higher concentrations in the sampler placed inside the line of privets than in the sampler placed 500 m away; in contrast, a windward direction during the second day made the amount of privet pollen captured in B higher than that in A.

The average daily distribution of olive and privet pollen in the atmosphere of the city over the last eight years (Fig. 3) reveals their different relative scale: maximum numbers of over 800 grains/m^3 for olive and of only 6 grains/mm^3 for privet. It is also worth noting the overlapping of the curves during late-May and the first fortnight of June.

Discussion

From the results it can be seen that there are marked differences between the airborne privet pollen concentrations collected with the permanent sampler situated in the city at a height of 15 m and the concentrations taken from samplers close to the source of origin at a height of 1.5 m. These differences could be a result of both the entomophilous character of this species and of the large size and weight of its pollen grains, which hamper long-distance transport of the released pollen. The small amounts of pollen recorded in the city airborne pollen spectrum during the past eight years could also be due to this (Figs 1,2). What is evident is that in areas where privet trees are used on a large scale as ornamentals, the pollen concentrations at a height of 1.5 m (i.e. human breathing height) can be very high, sometimes one-hundred times higher (Table 1, Day 3) than those detected a few kilometres away. Some studies have even revealed differences of 30–50% between the quantities recorded from two samplers in the same area, one at a height of 1.5 m and a second at 15 m above ground level (12–14).

Measurements taken in the three scenarios also reveal important information about the dispersion pattern of pollen grains once they are released into the air. From the results obtained in scenario 1 it can be deduced that, even over short distances, airborne pollen concentrations can differ greatly. This supports the hypothesis of locality for this pollen type. Distance of dispersion seems to be dependent on both the existence of architectonic barriers (Table 2) and wind direction (Table 3).

The role played by the design of the city leads us to think in terms of an urban island of biological pollution, in which pollen grains emanating from local sources are trapped in long, narrow avenues and do not mix with the surrounding air. With an effect similar to an urban heat island (15–17) the air is not renewed and, in consequence, the concentration of particles becomes higher. In addition to the biological material in the air, we also have to consider the nonbiological materials arising from human activities and in particular from traffic. The area studied supports a high density of traffic since it is one of the main routes from the industrial development zones to the city centre. This traffic activity generates a high quantity of solid waste that can be trapped in the canyon of streets in much the same way as pollen grains. Some studies have revealed a worsening of allergic symptoms as a result of the presence of inorganic solid compounds, such as diesel-exhaust particles (18, 19).

Wind direction may have a significant effect on the relative number of pollen grains found in the samples taken at some distance from the source of emission, in an open area. Any obstacle disturbing the free transport of pollen grains can prompt their accumulation on its windward face, while the vortex in the leeward face causes the particles to become re-suspended (20). In scenario 3 the pollen concentrations measured with a portable sampler placed 500 m from the source of emission of privet pollen, with no obstacles impeding the free flow of air, varied according to whether wind direction was towards or away from its position.

Another factor to consider is the privet (*Ligustrum*) flowering date. In this climate area the flowering period extends from late-April to the end of July, June being the month in which higher pollen concentrations can be detected in air samples. This part of the curve overlaps with the average flowering curve of olive trees (Fig. 3). It has already been reported that one of the major allergens of *Olea* pollen, Ole e 1, is also present in closely related Oleaceae species, such as *Syringa, Fraxinus* and *Ligustrum* (7). Two aspects of the allergenic character of *Ligustrum* pollen have already been documented: its reactivity with the common pollen allergens in Oleaceae (5, 7), and its cross-reactivity with other pollen types (6). But more importantly, *Ligustrum* pollen usually appears in the atmosphere when people have been suffering from pollen allergy for a long time. After at least one month's exposure, the threshold concentrations for symptoms to appear (priming) would be reached with only small amounts of pollen (21). A similar situation has been described in *Betula* pollen sufferers, when the initial air concentration of 80 grains/m^3 needed to produce a reaction at the beginning of the season decreases to only 30 grains/m^3 later in the season – or even less if pollen from species with common allergens (*Alnus* and *Corylus*) start to appear in the air (22, 23). It is worth noting that during the period in which measurements were taken (the first week of June 2000) the daily average concentrations of olive pollen were lower than 50 grains/m^3/day, since most of the plants had finished blooming. Although these quantities are not considered sufficient to cause discomfort in sensitized people (11, 24), the population living in the above-mentioned neighbourhood still complained (either to the authors personally or through the Pollen Information phone-line) about allergy symptoms. As a consequence an official report has been requested by the Local Department of Health.

In conclusion, through the sampling performed in this area we determined that privet pollen was the prevalent airborne pollen, and revealed that the remaining pollen types presented very low concentrations. Privet pollen should be considered as a potential causative agent of local allergy problems in areas presenting a combination of circumstances: extensive numbers of privets and certain aggravating urban characteristics. Nevertheless, further research is required into threshold tolerance levels.

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