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Airborne pollen concentrations, solid particle content in the air and allergy symptoms in Córdoba (Spain)

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Abstract

During 1991 and 1992, hourly measurements were taken of solid particulates (size, 22–25 μm), *Olea* and grass pollen and spores. The results were then compared with symptoms recorded in patients consulting the Allergy Unit during the period of highest pollen concentrations (April–June). The spore-trap slides were studied by spectrophotometry in order to analyse the total solid particulates content in the air as a possible synergic agent of the pollen. This allowed the volume of material present in the air to be determined and expressed as a percentage of total optical density (OD). Allergy symptom data were obtained from the study of subjective clinical records completed by patients, who were required to note down the severity of a selected series of symptoms every 4 h using a scale from 0–3. The results showed a clear link during the season between hourly peaks and pollen concentrations, and the different patterns of response associated with the dominant pollen types. An attempt has been made to determine whether a relationship exists between the increment of the optical density and the symptomatic response. The positive relationship encountered seems to indicate that a synergic agent takes an active part in the effects produced by pollen in the patients.

Keywords: Aerobiology; Allergenic pollen; Allergy symptoms; Solid particulates

1. Introduction

Airborne inorganic particles are derived both from natural sources and from human activity (Cawse and Tait, 1982). As well as affecting climate, these particles increase atmospheric pollution, modifying the quality of the air that we breathe and provoking various biological reactions in humans (Ali-Mohamed, 1991). These reactions are caused partly by the mechanical action of the particles themselves and partly by the adverse effect on the respiratory mucosae of chemical pollutants borne on the particle surface. The latter effect may have serious consequences when the most common pollutants, SO_x and NO_x, are modified by photochemical oxidation (Bohm, 1991) to form substances such as nitric and sulphuric acid. As this reaction is strongly influenced by diurnal light periodicity, it has both diurnal and seasonal variations.

In the industrialised world, these pollutants generally affect humans to a greater or lesser extent, particularly when present in very high concentrations. Indeed, there appears to be a close relationship between pollutant levels and mortality in cities such as Detroit (Schwartz, 1991). There is, moreover, a confirmed link between severe asthma attacks and the combined presence of air pollutants and pollen from some plant species (Rossi et al., 1993). It is thus important to establish to what extent the symptoms exhibited by pollinotics may be influenced by the presence of pollen/spores and/or other types of particles present in the air (mainly of inorganic origin).

A number of authors have investigated the correlation existing between pollutants (from biotic and abiotic origin) and the specific or generic symptoms presented by patients in the course of continuous monitoring. Common to these studies is either the use of diaries in which patients record their personal assessment of variations in a set of selected symptoms (Braun-Fahrlander et al., 1992; Nielsen et al., 1993), or the monitoring of the

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patient by means of objective techniques such as the measurement of peak expiratory flow (PEF) (Morrow-Brown, 1992; Lebowitz et al., 1992) during periods of maximum pollution. Other authors, however, have questioned the reliability of symptom analysis in the diagnosis of atopic allergy (Vervloet et al., 1991; Charpin et al., 1993).

Despite these objections, Morrow-Brown's study illustrates the value of symptom-monitoring when studying the reaction of pollinotics to changes and variations in the level of certain airborne pollen antigens. Many hay fever sufferers present symptoms not correlated with the daily average pollen concentration, suggesting that immediate reactions may be triggered by transitory peaks rather than mean daily counts.

This hypothesis is supported by the fact that nasal provocation tests using grass pollen produce immediate reactions because allergens are released within seconds of wetting. It may be concluded from this that the relationship between allergen and the sensitized patient is extremely complex, because the severity of the symptoms depends not only on the amount of allergen inhaled but also — and primarily — on the response threshold of the sensitized subject, influenced by the priming effect at the start of the season and often modified by suppressive drugs.

In order to test this hypothesis in Córdoba (Spain), a city whose epidemiological, aerobiological and climatological characteristics (Domínguez-Vilches et al., 1993a) differ markedly from those of, for example, Derby (UK), and in order to establish the extent to which responses may be governed by factors other than pollen/spores, such as relative solid non-biological origin particle content, a preliminary study was performed during the spring. Future studies will cover the whole year, in an attempt to learn more about this cause-effect relationship and thus characterise the response to different antigens. It is hoped the data obtained will lead to improved immunotherapeutic and symptomatic treatment for pollinotics, or at least enable preventive measures to be taken to avoid contact with the antigen during maximum response periods.

2. Materials and methods

2.1. Aerobiological sampling

Aerobiological data were obtained from a new Burkard (Burkard Manufacturing Co. Ltd.) 7-day spore-trap placed on the roof of the Faculty of Sciences, a building situated at the University/Hospital campus in the city of Córdoba, just 200 m away from the main City Hospital building. The air flow was fixed at a rate of 10 l/min. The sampler was run in 1991 and 1992 from 1 April to 30 June. Readings were taken on four continuous horizontal scans, and results were subsequently extrapolated for the whole sample (Domínguez-Vilches et al., 1992).

This study is based only on data for the two main local pollen allergens, *Olea* and Poaceae (Domínguez-Vilches et al., 1993b). Given that these taxa flower exclusively in spring, the other variables utilised here refer only to the period from April to end-June each year.

Pollution measurements concern only solid particles (broadly of abiotic and biotic origin). As a rapid and economical method, we used the technique described by Leuschner and Boehm (1981) and Boehm and Leuschner (1989), which takes advantage of the same slides obtained for pollen analysis, enabling airborne particle content to be indirectly determined via the spectrophotometric measurement of optical density of the slides.

2.2. Optical density measurement

For the photometric scanning of the samples, we used a Beckman-DU7 (Beckman, Palo Alto, CA) spectrophotometer with a gel-scan function allowing the absorbance of each millimeter of the preparation at 400 μm to be ascertained. A blank in the form of a non-exposed spore trap slide was used for calibration.

2.3. Methods

For the quantification of patients' subjective symptoms, medical scorecards were kept. These enabled aerobiological data to be correlated with clinical data. The symptoms were selected on the basis of experience with pollinotics at the Allergy Unit of the University Hospital and include those most prevalent in the pollinosis syndrome; they can be grouped under three general headings: conjunctival, nasal and bronchial symptoms. For each symptom, the patient was given a daily chart covering a full month; each day was subdivided into four sections corresponding to four periods of the day: morning (08:00–12:00 h), afternoon (12:00–16:00 h), evening (16:00–20:00 h) and night (22:00 h onwards). The patient filled in this daily record-sheet before going to bed, scoring each symptom on a scale of 0–3. For each symptom, the maximum daily score was therefore 12. Mean values were obtained for each symptom by adding together scores obtained for each period of the day and dividing the result by the number of patients complaining of that symptom.

In the first year, 100 diagnosed pollinotics were given scorecards; 70% of them filled the cards in correctly and regularly. In the second year, only 50 scorecards were given out to the same group of patients, since 50 randomly-selected pollinotics received immunotherapy and consequently were not enrolled in the second year study. Twenty-three of the scorecards (46%) were filled in correctly and regularly. The inter-year difference in

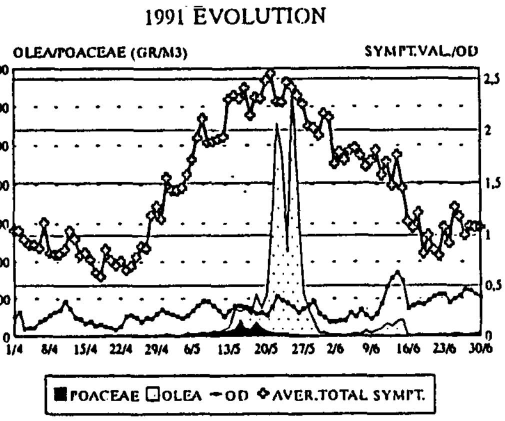

Fig. 1. Evolution of pollen and particulate concentrations and associated symptoms during 1991 (the values of the optical densities are multiplied by 10).

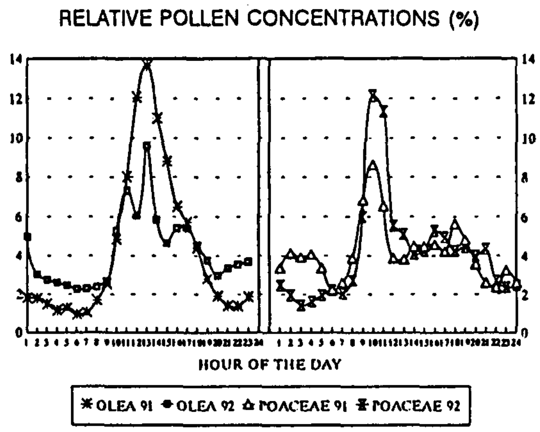

Fig. 3. Intradiurnal variation of the *Olea* and Poaceae pollen concentrations during the 2 years.

patient numbers may be accounted for by a decrease in olive pollen severity in the second year of study.

3. Results and discussion

3.1. Pollen data

Pollen counts for the 2 years studied differed significantly. The average (± S.D.) for the *Olea* season was 1516 ± 785 grains/m^3 for 1991 and 591 ± 517 grains/m^3 for 1992, $F = 6.65$ for 99.99% probability; the season average counts for Poaceae were 51.4 ± 16.88 grains/m^3 for 1991 and 30.4 ± 12.10 grains/m^3 for 1992, $F = 2.86$ for 99.99% probability. In 1991, the highest olive-pollen count was recorded since 1980 (the year when aerobiological sampling began in Córdoba); there was also a less dramatic increase in pollen counts for other taxa in the area. Airborne pollen concentrations in 1992, however, ranged from low to medium, mainly due to the spring and winter drought and, paradoxically, to heavy rain and a sharp fall in temperatures during the pollen season (Figs. 1,2).

The other taxa studied, including Poaceae, recorded significantly lower values in 1992, with decreases of around 0.33–0.4. Attention should be drawn to the virtually overlapping Poaceae and *Olea* seasons in 1992, due to early flowering of the olive.

Another notable finding was a greater degree of uniformity in the Poaceae distribution curve for the second year.

The intradiurnal pattern curves for both years showed a distribution resembling that already described for this area in other years (Galán et al., 1991), with a morning peak for Poaceae and an afternoon-evening peak for *Olea* (Fig. 3).

3.2. Optical density

The optical density curve for the first year shows a highly irregular distribution, tending to increase at the

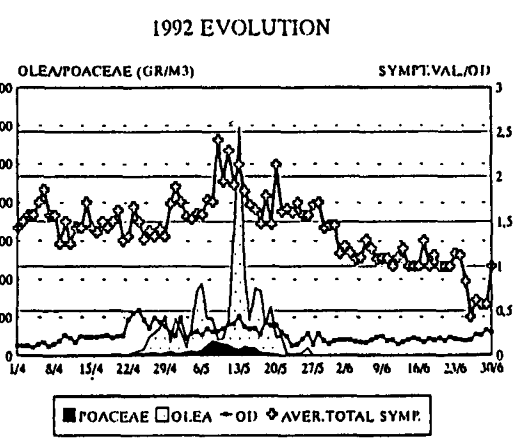

Fig. 2. Evolution of pollen and particulate concentrations and associated symptoms during 1992 (the values of the optical densities are multiplied by 10).

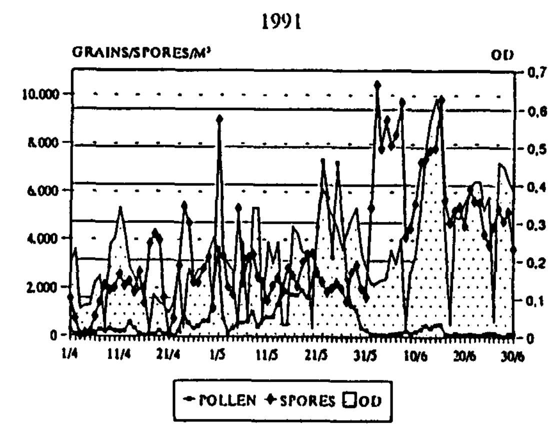

Fig. 4. Variation of optical densities in relation to the pollen and spores concentrations during 1991.

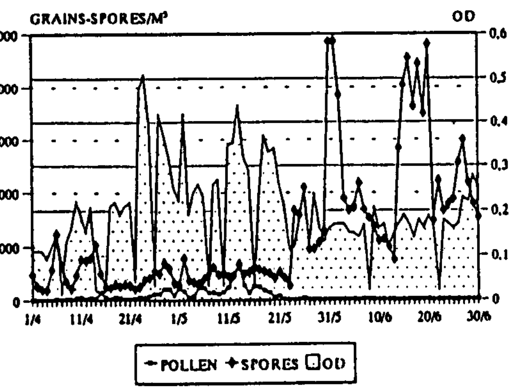

Fig. 5. Variation of optical densities in relation to the pollen and spores concentrations during 1992.

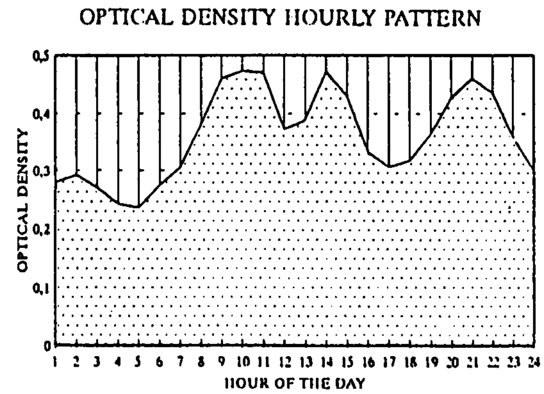

Fig. 6. Optical density intradiurnal pattern (average of the 2 years).

end of spring, and with peaks more than twice the mean value. These may be due to the strong south-easterly winds during this period, which tend to carry most suspended dust particles (Fig. 4). The curve for 1992 is also irregular, though the trend is the reverse of that for 1991. Two peaks are notable at the height of the pollen season (May 1 and 19), with values more than twice the mean value for the period (Fig. 5).

The results of the Pearson correlation analysis for pollen counts and optical densities are difficult to interpret. In years with high pollen counts, one might reasonably expect a strong correlation with optical densities, whereas the present results yield only one positive correlation (99%) in 1992, the year with the lowest seasonal pollen count (Table 1A). Given the particular meteorological characteristics of 1992, with unusually heavy rainfall in May–June, it is not surprising that there should be an increase in fungal spores at the end of the season, with daily mean values of 24 000 spores/m^3 (Fig. 5). However, there was no significant positive correlation between these high concentrations and the optical densities recorded, which suggests that the fungal species involved should be mainly those producing hyaline or low-pigment spores. This apparent relative lack of correlation may indicate that optical density figures may be essentially due to the relative presence or absence of non-pollen solid particles.

Intradiurnal variations in optical density followed a clear pattern in both years, with three peaks (07:30–09:30 h; 13:30–14:30 h and 20:00–21:30 h) (Fig. 6). This pattern indicates that, at least in the present case and for the period under study, intradiurnal variation could be largely dependent on motor vehicle traffic: OD peaks broadly correspond to periods of maximum road traffic in the city (rush hours), and may thus be related to the degree of atmospheric pollution caused by petrol and diesel combustion fumes containing SO_x and NO_x..

3.3. Symptoms quantification

The manifestation of symptoms appears to follow a clearly seasonal pattern, corresponding to variations in the pollen count. Total symptom manifestation cor-

Table 1
A. Correlations between optical densities measurements and pollen counts

	Olea	Poaceae	*Olea* + Poaceae
1991 and 1992	0.3036**	0.2069*	0.3194**
1991	0.1813	0.0359	0.1584
1992	0.4977**	0.4387**	0.5364**

B. Pearson correlations between pollen counts, optical densities and symptoms

	Olea	Poaceae	*Olea* + Poaceae	O.D.
1991 and 1992	0.4952**	0.5787**	0.6416**	0.1867
1991	0.5725**	0.7230**	0.8107**	0.0547
1992	0.6871**	0.7147**	0.7940**	0.4752**

2184 data (counts) were used each year corresponding to hourly measurements over the 91 days (91 × 24).
*99% significance.
**99.9% significance.

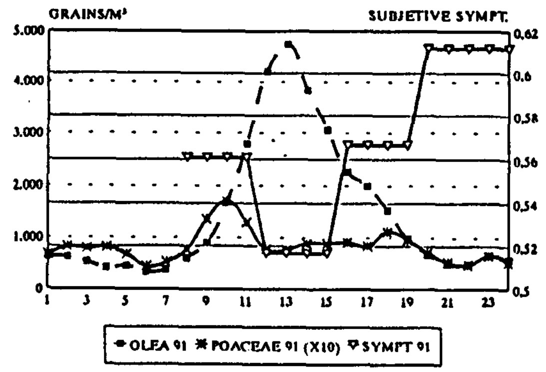

Fig. 7. Intradiurnal variation of symptoms in relation to the hourly total pollen concentrations during the pollen study of 1991.

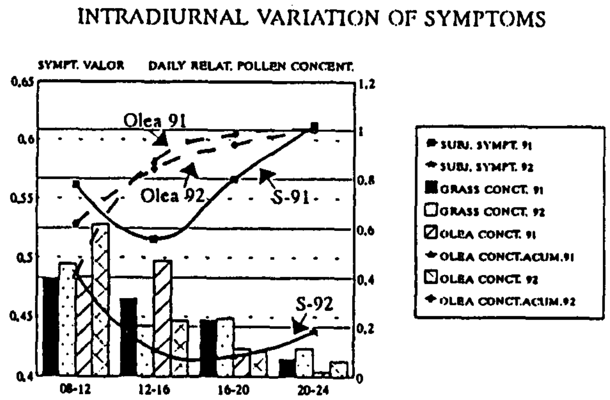

Fig. 9. Intradiurnal variation of symptoms (grouped every 4 h) in relation to the relative pollen concentrations and the cumulative curve of the *Olea* pollen concentrations.

related positively (99%) with pollen concentrations (Table 1B). However, the patients' overall self-assessment does not appear to be greatly influenced by pollen intensity over the season as a whole. This apparent anomaly may in part be due to the restricted scoring scale available for the patient (0–3), although a wider scale would almost certainly have proved difficult to use for the patient. However, it may also reflect the replacement of certain symptoms by others depending on the antigen prevailing each year. In 1991, there was a clear predominance of *Olea*, while in 1992, Poaceae had a higher relative proportion. This difference may give rise to a different characterisation of symptoms for each year.

The symptom peaks generally recorded were clearly related to periods of maximum pollen intensity of the two primary airborne allergens. However, other peaks are more difficult to account for, or can only be attributed to the addition of high OD values plus discrete amounts of pollen grains. The base level of symptoms was high at the beginning and end of the season, as well as on days with low pollen counts; this may be attributed to polysensitisation and/or to chronic factors (Domínguez-Vilches et al., 1993b).

Considering only *Olea* and Poaceae, results show that in 1991 — when pollen counts were high — symptoms were more acute. Results also indicate that much lower concentrations of Poaceae triggered very similar subjective responses, suggesting that the allergenic value of Poaceae is in fact higher than that of *Olea*. *Olea* is therefore the main pollen allergen in this area only because of the very high concentrations reached, rather than because of its allergenic value (Figs. 1,2).

With regard to the intradiurnal variation of symptoms in relation to daily pollen count curves, graphs representing days when *Olea* or Poaceae pollen counts were higher than seasonal means are shown in Figs. 7 and 8. These curves show a different pattern for each year: depending on the relative predominant antigen, symptoms peaks are recorded at different times of the day.

It is also evident from the graphs that in 1991, when *Olea* pollen reached very high concentrations indeed,

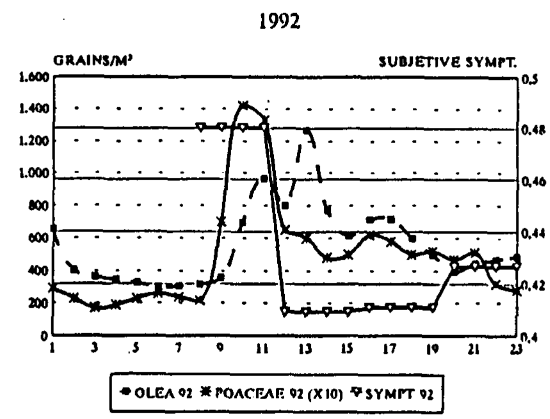

Fig. 8. Intradiurnal variation of symptoms in relation to the hourly total pollen concentrations during the pollen study of 1992.

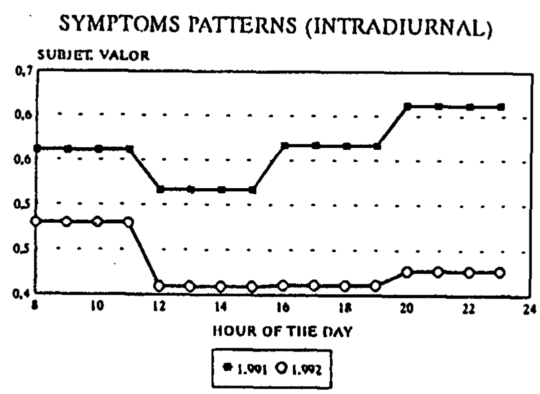

Fig. 10. Intradiurnal pattern of symptoms for the period 1 April to 30 June in 1991 and 1992.

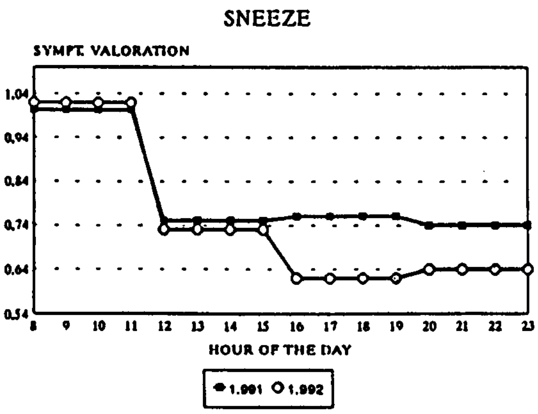

Fig. 11. Intradiurnal pattern of the evaluation of the symptom 'sneeze' in the 2 years.

the allergic response was delayed with respect to pollen peaks, and appeared to be related more to accumulated pollen levels than to daily maxima. Total symptoms peaks started when the inflection-point was reached on the accumulated pollen curve. The more pollen accumulated, therefore, the higher the total symptom assessment (Fig. 9). By contrast, in 1992, when Poaceae concentrations were relatively higher, symptoms peaked simultaneously with pollen peaks, agreeing with findings reported by Morrow-Brown (1992).

A greater seasonal pollen intensity was reflected in a higher assessment of daily symptoms (Fig. 10).

Finally, a separate analysis was made of the single symptom recording the highest scores over both years, which proved to be sneezing (average, 1991: 3.68 ± 0.65; average, 1992: 3.73 ± 0.45; for the entire season: 4.29 ± 0.39 and 3.96 ± 0.54, respectively for days with counts above the average) (Fig. 11). In view of the foregoing considerations, sneezing would appear to be more closely linked to Poaceae than to *Olea* antigen, since the greatest response was reported for the early hours of the morning, with a slightly higher afternoon/evening score in 1991, corresponding to the influence that year of *Olea* pollen.

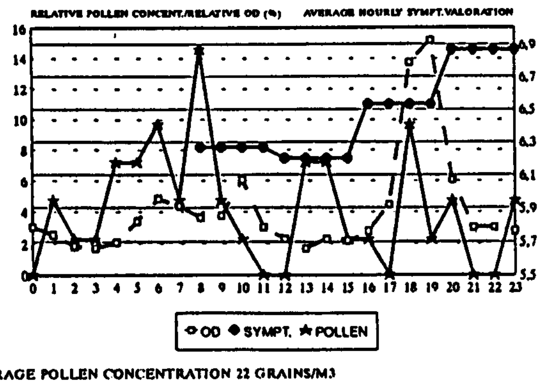

Fig. 12. Relative hourly pollen concentrations, optical density and evaluation of symptoms on days of low pollen counts and high optical density.

Intradiurnal study of the days with pollen counts below 50 grains/m^3 and high OD values (Fig. 12) appears to indicate a relationship between increases in OD and the symptoms onset whenever they coincide with periods of maximum relative pollen concentration.

4. Conclusions

The results obtained suggest that the symptoms onset follows a marked pattern, linked mainly to increases in pollen concentrations. Nevertheless, the allergenic value of Poaceae pollen appears to be much greater than that of *Olea* pollen; the latter may thus be considered the principal allergen in this area only in terms of the high concentrations reached rather than in terms of its allergenic value.

It is interesting to note that the pollen release-symptom response pattern postulated by Morrow-Brown (1992) was confirmed in the case of Poaceae, although not for *Olea*, where there was a considerable time-lag between pollen peaks and symptom peaks, with a considerable worsening of symptoms during the sleeping hours. Moreover, the quantitative importance of daily peaks seemed to have less influence on allergic response than did the quantity of pollen accumulated throughout the day.

Given that the patterns obtained in spring for intradiurnal variation in optical density appear to depend to a great extent on road traffic, there may be a synergic relationship with pollen, giving rise to a worsening of symptoms. For that reason, the combined use of Hirst-type spore trap samplers and spectrophotometer readings of the slides may prove a rapid and easy method of measuring abiotic pollution.

Finally, it is felt that the reliability of the present results could readily be confirmed if it were possible to implement parallel, more objective, methods such as measurement of IgE levels in the patients studied. This procedure would unfortunately be hindered by the need for patients leading normal lives to attend the hospital for tests every 4 h.

Acknowledgements

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