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Diurnal variation of airborne pollen at two different heights

P. Alcázar, C. Galán, P. Cariñanos and E. Domínguez-Vilches

Department of Plant Biology, Faculty of Science, Universidad de Córdoba, Spain

SUMMARY

The diurnal variation in airborne pollen concentrations in the air of Córdoba at two different heights (1.5 m and 15 m) was studied during 2 consecutive years with the help of two Hirst volumetric samplers. According to pollen percentages obtained every hour, we determined whether every taxon studied presented a morning or an afternoon pattern, and whether this model was homogeneous (with a slight difference between the time of maximum and minimum reading) or heterogeneous (with a large difference between the two readings). We observed that the taxa that had many species in the area, such as Plantago, Poaceae, *and* Chenopodiaceae-Amaranthaceae *showed a homogeneous model, while those taxa with few species present, such as* Cupressaceae *and* Urticaceae *showed a more heterogeneous model. Furthermore, the pattern of the plants with a large presence in the study area was more heterogeneous at 1.5 m because the pollen collected at this height is released from anthers. In the sampler placed at 15 m we detected airborne pollen, found that the curves were smoother and also observed a slight time delay for the taxa that were highly present in the area of study.*

Key words: Diurnal variation - Airborne pollen - Pollen at different heights

INTRODUCTION

The pollen content in the air varies throughout the day. For the taxa present in the area of study, the diurnal variation depends on the moment pollen is released from the plant into the air and on the length of time they remain suspended in the air. It also depends on weather conditions, as has been proved by many authors (1-3). In the case of taxa registered far from the sampling point, the movement of air masses determines the time of day that maximum concentrations are registered (4). Norris-Hill and Emberlin (3) described a very special daily variation for grasses in London, England, given that they were scarcely represented in the sampling area, with their maximum pollen concentration appearing between 6 p.m. and 10 p.m.

Studies on diurnal variation have generally been carried out at a height of 15-20 m above ground level. However, they have rarely been carried out at human height. Such a test would at least theoretically make it possible to determine how pollen concentrations vary throughout the day at the height where human beings breathe (4-7).

In this study, we analyzed the diurnal variation in pollen concentrations of the six most abundant taxa in the air of Córdoba with allergenic pollen (*Poaceae, Olea europaea, Cupressaceae, Plantago* sp., *Urticaceae* and *Chenopodiaceae-Amaranthaceae*) at two different heights *i.e.*, 1.5 m (human height) and 15 m (standard sampling height). The total pollen registered for all the pollen types present in the air was also studied at the two heights. Thus, we aimed to determine the importance of sampler height when studying diurnal variation.

MATERIALS AND METHODS

We used two Hirst samplers (Burkard spore-trap) placed at the Faculty of Sciences in Cordoba, situated west-southwest of the outskirts of the city in an open area. One sampler was placed at a height of 15 m (sampler A) and the other at 1.5 m (sampler B); no actual horizontal distance was put between them. The sampling was carried out over 2 consecutive years (1991 and 1992).

In order to analyze the samples, we made four continuous horizontal sweeps at a magnification of x400

for the taxa under study, while the total amount of pollen was registered through one single sweep in the middle of the tape to simplify the task. We used this method to obtain the hourly pollen concentration. Results were multiplied by a factor in order to express the number of pollen grains per cubic meter of air per hour. We obtained the average pollen concentration for each taxon by dividing the total amount of annual pollen by the number of days in the season (the period in which 98% of the total annual pollen amount was detected was considered the pollen season). We only used the days in which the concentration was equal to or larger than the average concentration, and those without rain. We then calculated the total and average concentration in each hour to obtain a value for each hour of the day. Finally, with these values we obtained a percentage for each hour, thereby obtaining an ideal day.

The pollen percentages obtained for every hour are represented in Figures 1 and 2. We have indicated whether each taxon had a morning or an afternoon pattern. Whether it showed a homogeneous pattern (slight difference between maximum and minimum at the different hours of the day, with the maximum peak representing less than 15% of the total pollen) or heterogeneous pattern (large difference between the minimum and the maximum, the maximum peak representing more than 15% of the total pollen) was also taken into account. This was done according to the two groups obtained by Galan *et al.* (1) in Córdoba using an analysis of centered data to represent the behavior of the different pollen types.

During the second year we carried out a more detailed study of the *Urticaceae* and *O. europaea* pollen. In the case of the former, we separated the two pollen types in this family into *Urtica urens-Parietaria* spp., with a 3-zonoporate pollen (14-20 μm), and *Urtica membranacea*, with a 6-8 pantoporate pollen (9-12 μm). We studied the first days in which *O. europaea* pollen was detected in the air, probably due to the olive trees near the sampling area. We also took into account the days in which the maximum peaks of airborne pollen were detected, this pollen probably arising from more distant olive trees in the south of the province of Córdoba where the biggest concentrations of olive trees can be found.

The timing referred to in the results is Spanish official time (+2GMT).

RESULTS

The pollen distribution pattern throughout the day was very similar for both samplers (Figs. 1, 2). The pollen concentration was generally higher during the midday hours and maintained high values in the afternoon, although with lower concentrations in most cases because of airborne pollen. During the night, levels decreased due to the low emission by plants and to the deposition of airborne pollen. During these hours the atmospheric stability makes vertical transportation difficult (8).

Some taxa showed a clearly homogeneous pattern, with a slight difference between their minimum and maximum peak. This was the case for the *Poaceae* family, which showed a maximum peak representing only 12% of the total pollen registered. The pollen concentrations of this family showed a clear morning pattern (Fig. 1). Its highest concentrations were registered from 9:00 a.m. to 12:00 p.m. for both years and in both samplers, with a small peak in the afternoon.

A homogeneous pattern was also shown by the *Chenopodiaceae-Amaranthaceae* families and the *Plantago* genus, especially in those readings obtained through the higher placed sampler. These readings showed slightly defined curves with several peaks throughout the day with very similar percentages. Its maximum peak percentage accounted for only 10% of the total pollen registered in the case of the *Chenopodiaceae-Amaranthhaceae* families (Fig. 2) and 9% for the *Plantago* genus (Fig. 1). Although the pollen concentrations of these plants were distributed throughout the day, their percentage was a little higher at noon or in the afternoon. In the case of the *Plantago* genus, we found that it showed a bimodal character as it had a maximum peak at noon and another one in the afternoon, which might have been due to the blossoming of the different species of this genus.

Although *O. europaea* showed a homogeneous pattern (Fig. 1) in the years in which a high concentration was registered, as shown in the first year of study, it tended to be more heterogeneous (the maximum represented 14% of the total pollen registered). Nevertheless, we had to take into account that its annual concentration curves had to show a different pattern in both samplers depending on whether we were at the beginning or the end of the pollen season. This was probably due to the fact that olive trees near the area of sampling blossom before the ones further away, as we have already proven (9). In Figure 3 we show both the first days of the season in which the pollen was registered and the days in which the biggest concentrations of this pollen type were detected. At the beginning, when only the olive trees near the sampling area had blossomed, the curve was much more heterogeneous at 1.5 m. This pollen type followed a noon-afternoon pattern (Fig. 2), the highest concentrations being registered between 11 a.m. and 5 p.m. The curve varied from 1 year to the next because these 2 years had a very different pollen reading.

On the contrary, *Urticaceae* and *Cupressaceae* families showed heterogeneous patterns. The former (Fig. 2) had a very pronounced curve, which was more

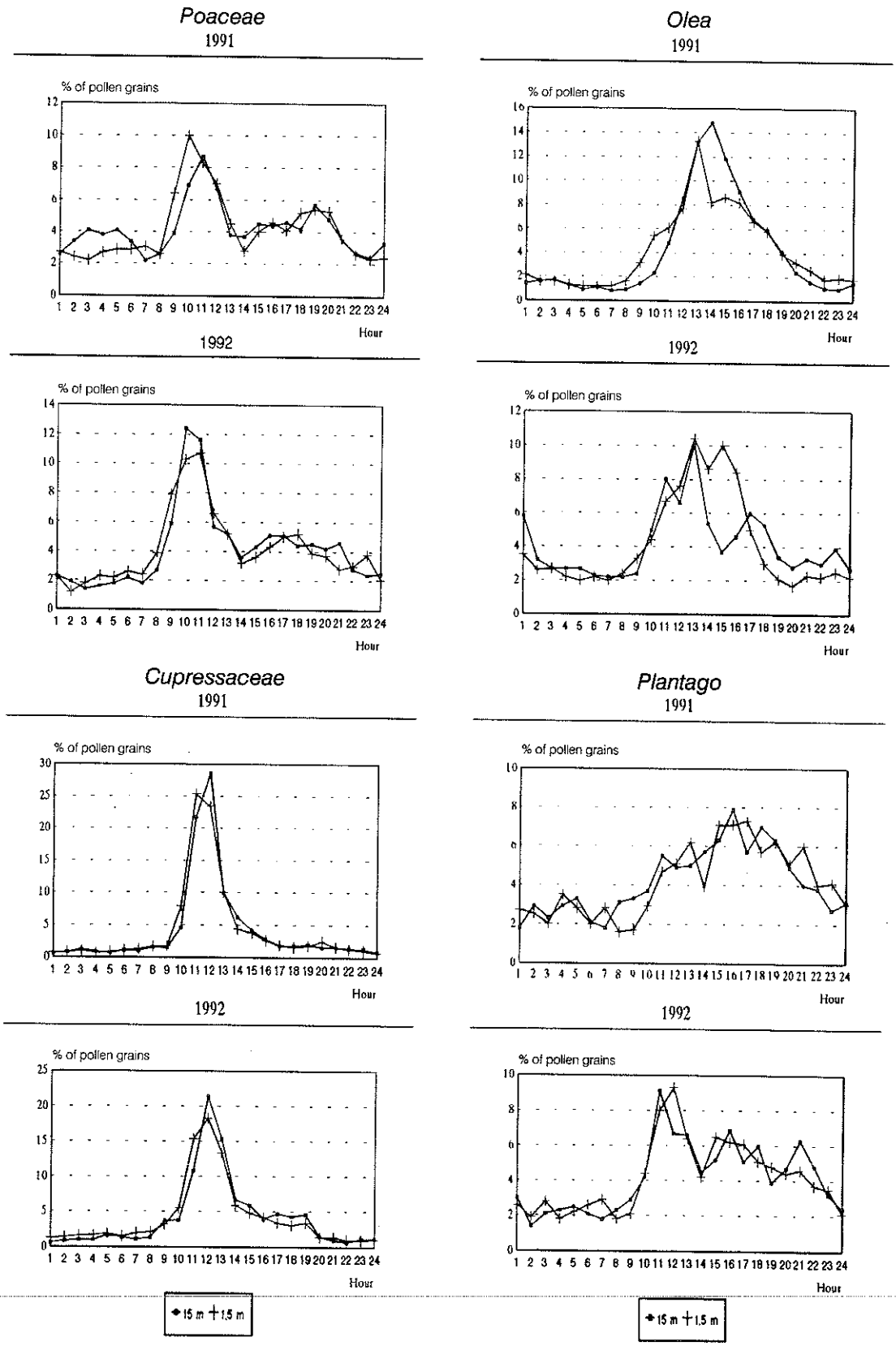

Fig. 1. Diurnal variation patterns of Poaceae, Olea europaea, Cupressaceae *and* Plantago *pollen grains at two different heights.*

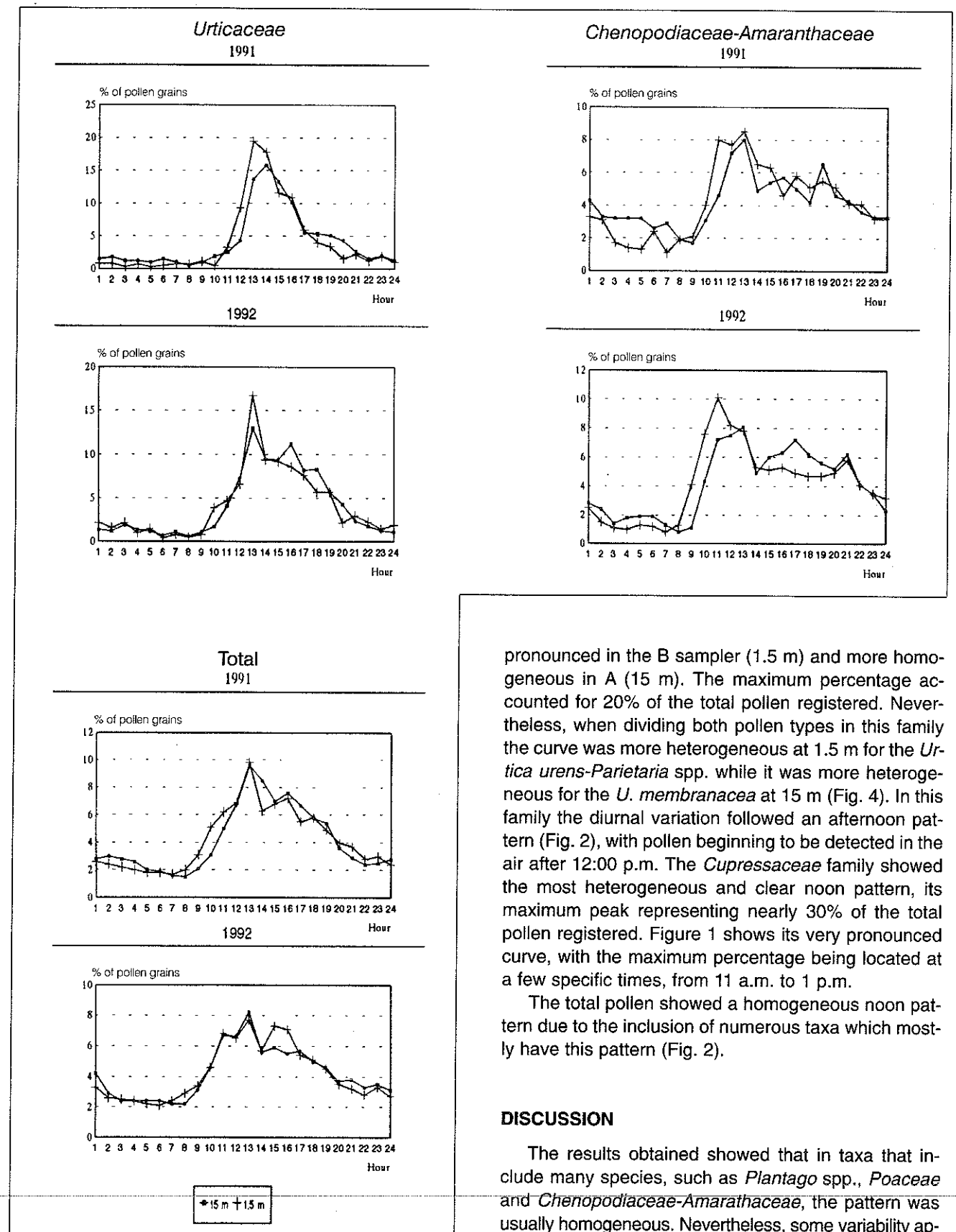

Fig. 2. Diurnal variation patterns of Urticaceae, Chenopodiaceae-Amaranthaceae *and total pollen grains at two different heights.*

pronounced in the B sampler (1.5 m) and more homogeneous in A (15 m). The maximum percentage accounted for 20% of the total pollen registered. Nevertheless, when dividing both pollen types in this family the curve was more heterogeneous at 1.5 m for the *Urtica urens-Parietaria* spp. while it was more heterogeneous for the *U. membranacea* at 15 m (Fig. 4). In this family the diurnal variation followed an afternoon pattern (Fig. 2), with pollen beginning to be detected in the air after 12:00 p.m. The *Cupressaceae* family showed the most heterogeneous and clear noon pattern, its maximum peak representing nearly 30% of the total pollen registered. Figure 1 shows its very pronounced curve, with the maximum percentage being located at a few specific times, from 11 a.m. to 1 p.m.

The total pollen showed a homogeneous noon pattern due to the inclusion of numerous taxa which mostly have this pattern (Fig. 2).

DISCUSSION

The results obtained showed that in taxa that include many species, such as *Plantago* spp., *Poaceae* and *Chenopodiaceae-Amarathaceae*, the pattern was usually homogeneous. Nevertheless, some variability appeared from one year to the next with regard to the time of maximum reading. This was due to the weight of the different species in the total spectrum, which also

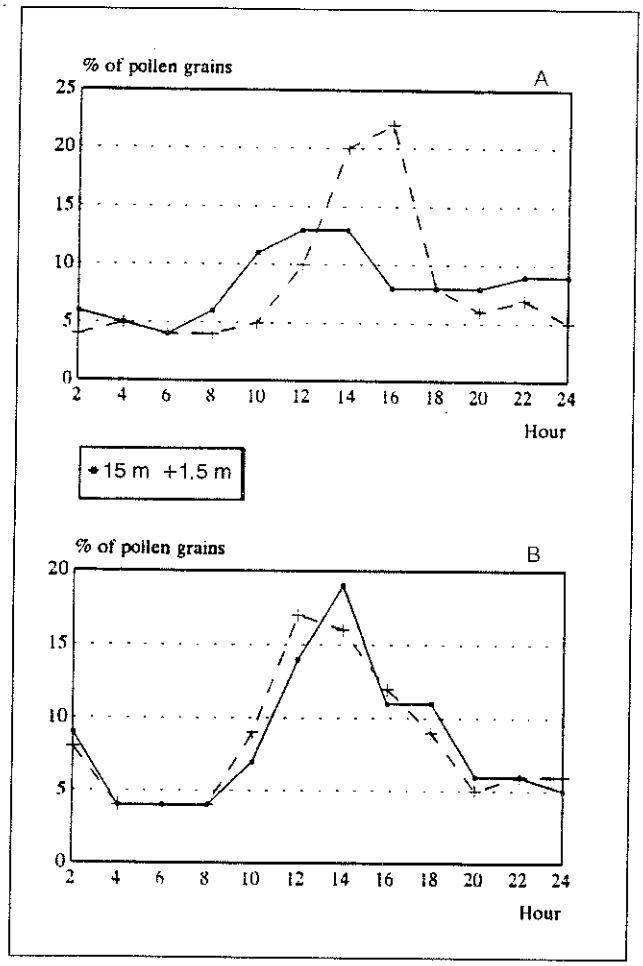

Fig. 3. Diurnal variation patterns for Olea europaea *at the start of the 1992 pollen season (A) and the days with maximum pollen concentration for the 1992* Olea europaea *pollen season (B).*

depended on the weather conditions. On the contrary, the *Urticaceae* and the *Cupressaceae* families, with few species in the area, showed a heterogeneous pattern. Although Rantio-Lehtimaki *et al.* (6) obtained a very homogeneous pollen concentration throughout the day for all arboreal species, in our area, *Cupressaceae* showed a heterogeneous diurnal curve.

Our results show that diurnal variation is strongly related to the season of the year in which blossoming takes place. Plants that blossom in the spring, and especially those with a later blossoming such as the *Chenopodiaceae-Amaranthaceae* families which blossom in summer, showed a larger percentage of pollen at daybreak at the higher elevation. This was due to the fact that convective phenomena, which are very frequent on summer afternoons, cause pollen to rise, and it then remains suspended throughout the night (Fig. 2). On the other hand, in plants that blossom in winter, such as the *Cupressaceae* family, pollen grains throughout the night are practically absent (Fig. 1). As Giostra *et al.* (8) have stated, atmospheric stability at night makes vertical transportation difficult. This is especially true in winter given the thermal inversions. Thus, this family shows a heterogeneous pattern.

Plants with a large presence in the area of study showed more heterogeneous curves at 1.5 m since the pollen collected at human height mostly coincided with cycles of release from the anthers. However, at the higher level airborne pollen was detected, which caused the curves to be smoother and without such a pronounced maximum peak. This is in keeping with results previously published by Kapyla (4). In our study, this was more evident in the *Urticaceae* and *Chenopodiaceae-Amaranthaceae* families.

The separate study of both pollen types of the *Urticaceae* family showed different behavior for each of them. For the *Urtica urens-Parietaria* spp. pollen type the curve obtained at 1.5 m was more heterogeneous as the maximum reading corresponded to pollen dispersion from plants. On the contrary, for *U. membranacea* the curve obtained was more heterogeneous at 15 m as this small sized pollen rises rapidly to higher layers of the air due to the convective air currents frequent at noon and early in the afternoon, which has already been proven in earlier studies (9).

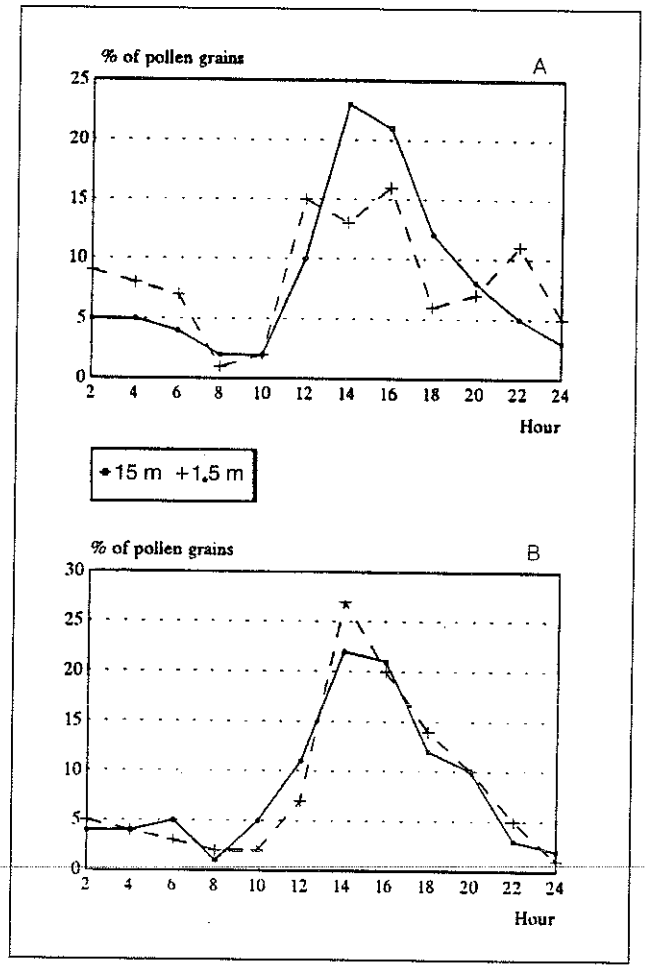

Fig. 4. Diurnal variation patterns for Urtica membranacea *(A) and* Urtica urens-Parietaria *spp. (B).*

In the case of *O. europaea*, it was clear that at the beginning of the blossoming period, when only the olive trees near the study area had blossomed, the curve obtained with the sampler placed at 1.5 m was very heterogeneous since the pollen reading must have coincided with the hours of pollen release from the tree. However, the sampler placed at 15 m showed a very homogeneous curve since some turbulence was necessary for the pollen to rise to a certain height, making readings possible because of the airborne pollen. During the days when the blossoming peak was registered, the pollen came mostly from a distant place due to the fact that the olive trees found in large expanses in the south of the province of Córdoba had blossomed. During this period, the curves obtained at both heights were heterogeneous and very similar given the fact that the air masses carried airborne pollen which was then captured simultaneously by both samplers. Nevertheless, during the morning, the percentage was greater at the lower height because the nearby olive trees were still in blossom. This sampler proved to capture pollen more efficiently for taxa present near the sampling point (Fig. 1).

We also observed a small time delay in the sampler placed 15 m high when dealing with taxa that were abundant in the area of study. For example, at the beginning of the curve when the liberated pollen from the anthers was detected, the *Poaceae, Cupressaceae, Urticaceae* and *Chenopodiaceae-Amaranthaceae* families showed a higher percentage in sampler B (1.5 m). Nevertheless, after an interval of a few hours it became higher in sampler A. According to the results of Rantio-Lehtimaki (10) in Finland, convective storms transport air masses up to 8 to 12 km high in half an hour. For *Plantago*, however, the curves in both samplers followed the same tendency, with a very similar pollen grain percentage being registered every hour in both samplers.

We may thus conclude that it is important to take into consideration the sampling height when carrying out studies on diurnal variation. At a lower height more accurate information on the times of pollen emission from the plants can be obtained, while at a greater height the data would be more appropriate for carrying out studies of pollen dispersion throughout the day. This information is of course also important for people who suffer from allergy, especially given the hourly pollen concentration at 1.5 m where people usually breathe.

RESUMEN

Se ha estudiado la variación intradiurna de la concentración de polen en el aire de la ciudad de Córdoba a dos alturas durante 2 años consecutivos. Las alturas seleccionadas han sido 15 m (altura estándar en los estudios de aerobiología) y 1,5 m (altura a la que normalmente respiran los seres humanos). El trabajo se ha realizado utilizando dos captadores volumétricos tipo Hirst que permiten conocer el contenido polínico de cada hora. Según los porcentajes se ha determinado para cada taxón si presenta un patrón de mañana o tarde y si el modelo de distribución de polen a lo largo del día es homogéneo (pequeña diferencia entre los registros polínicos obtenidos a la hora de máximo y mínimo contenido polínico) o heterogéneo (gran diferencia entre el contenido polínico de la hora de máximo y mínimo registro). Se observa que los taxa que incluyen muchas especies presentan un modelo homogéneo, mientras que los que presentan pocas especies en el área de estudio tienen un modelo heterogéneo. Además, el modelo de distribución de polen a lo largo del día para plantas bien representadas en el área de estudio es más heterogéneo a 1,5 m, pues a esta altura el polen registrado coincide en su mayoría con los ciclos de liberación desde las anteras mientras que a una altura superior se detecta polen en suspensión, siendo las curvas más suaves. También se observa un pequeño retraso a 15 m cuando se trata de plantas bien representadas en el área de estudio. Las plantas de floración estival presentan un mayor contenido polínico durante la noche pues los fenómenos convectivos frecuentes en las tardes de verano provocan un ascenso de polen que permanece suspendido a lo largo de la noche mientras que las plantas que florecen en invierno presentan un contenido polínico prácticamente nulo durante la noche. En el caso de la familia Urticaceae, *se han separado los dos tipos polínicos que presenta. En el tipo* Urticaurens-parietaria *la curva es más heterogénea a 1,5 m, mientras que en* Urtica membranacea *es más heterogénea a 15 m, ya que este polen de pequeño tamaño asciende rápidamente a capas más altas de la atmósfera gracias a fenómenos convectivos frecuentes durante el mediodía y la tarde. En el caso del olivo se observa la importancia de la distancia de las plantas a la zona de muestreo: al principio, cuando sólo están en flor los olivos cercanos al área de estudio la curva obtenida a 1,5 m es muy heterogénea, mientras que a 15 m es muy homogénea. Sin embargo, cuando florecen las grandes extensiones de olivos del sur de Córdoba, en ambos casos las curvas son heterogéneas y muy similares pues los registros dependen de las masas de aire que traen el polen desde el sur. Estos estudios son de gran utilidad para las personas que sufren polinosis ya que pueden planificar sus salidas y tomar precauciones conociendo cómo varía el contenido polínico a lo largo del día, especialmente a la altura a la que normalmente se respira.*

Palabras clave: Variación intradiurna - Polen aerovagante - Polen a diferente altura

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Correspondence: Purificación Alcázar Teno, Departamento de Biología Vegetal, Facultad de Ciencias, Universidad de Córdoba, Avenida de San Alberto Magno s/n, 14.004 Córdoba, Spain.