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A study on non-arboreal pollen collected during ten consecutive years in the air of the SW Spain

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A study on non-arboreal pollen collected during ten consecutive years in the air of the SW Spain

Effect of drought period on pollen spectrum

FRANCISCO JOSE GONZALEZ MINERO, PILAR CANDAU, JULIA MORALES and CARMEN TOMAS

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A Cour trap was used to sample the air of the city of Seville continuously from 1987 to 1996, both inclusive. The most important climatological feature of the period was a prolonged drought, which began in 1990 and reached its severest moment in 1995 after six consecutive years without exceeding the mean annual precipitation for the city.

The study was conducted on the 16 pollen types that appeared in amounts greater than 0.05% of the total pollen collected in the ten-year period: Poaceae, Urticaceae, *Plantago*, Chenopodiaceae-Amaranthaceae, Asteroideae, *Rumex*, *Mercurialis*, Brassicaceae, *Helianthus*, Lactucoeidae, *Typha*, Cyperaceae, *Echium*, Apiaceae, *Artemisia* and Leguminosae.

The aspects examined were the possible effect of the drought on the variation, over the years, in the annual total pollen concentrations; the relationship between the non-arboreal vegetation of the region and the quantitative composition of the pollen spectrum; and the description of the pollen curves (the variation, through the year, in the weekly pollen concentrations) of the pollen types in the study.

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The continuous, regular aerobiological monitoring of Seville was begun in 1987, using several Cour traps installed in different points of the city. This sampling produced various results: a pollen calendar of the city (González Romano et al. 1992), phenological works (González Minero & Candau 1997), and crop-forecasting studies (Candau & González Minero 1997). Cour traps are not currently being used in Seville; they were replaced by Burkard samplers when our research group became part of the Red Española de Aerobiología (Spanish Aerobiology Network). As a result of the large amount of data available, we have decided to present this first article, which studies the non-arboreal pollen collected in the air of Seville from 1987 to 1996, and which is intended as a reference point for southern Mediterranean cities. It also studies the impact of the drought on the variation of the annual total pollen concentrations over the years.

GEOGRAPHIC AND CLIMATOLOGICAL SITUATION AND VEGETATION OF THE STUDY AREA

The city of Seville is one of the most heavily populated of Spain. It is located in the south-west of peninsular Spain (37°23'N, 5°58'W) in the Guadalquivir valley, on the banks of that river. The city is 40 kms from the Gulf of Cádiz (Atlantic Ocean).

The climate of the city is Mediterranean, with mild winters

and prolonged dry summers. The annual mean temperature is 18.8°C, and the mean total annual rainfall is 602 mm [data supplied by the Tablada (Seville) regional centre of the National Meteorological Institute]. The latter figure is only a guide, as one of the climatological characteristics of the area is the alternation of dry years, when the annual mean is below 600 mm, with exceptionally wet years. The number of hours of sunshine annually is 2877.

The non-arboreal vegetation potentially affecting the pollen spectrum can be divided into three groups: nitrophilous-ruderal communities, halophyte and marsh communities typical of the natural vegetation, and agricultural crops.

The nitrophilous-ruderal communities are not very different from those described for other large urban nuclei, and appear on building sites, wasteland, walls, field borders, and paths: Amaranthaceae (*Amaranthus*), Apiaceae (*Amni*, *Daucus*, *Oenanthe*, *Peucedanum*, *Scandix*, *Thapsia*), Boraginaceae (*Echium plantagineum*), Brassicaceae (*Alyssum*, *Capsella*, *Thlaspi*, *Diplotaxis*, *Hirschfeldia*), Chenopodiaceae (*Chenopodium*, *Beta*), Asteraceae (*Achillea*, *Anthemis*, *Bellis*, *Calendula*, *Chamaemelum*, *Chrysanthemum*, *Andryala*, *Carduus*, *Centaurea*, *Chichorium*, *Taraxacum*, *Tolpis*, *Artemisia crithmifolia*, *A. caerulea*, *A. absinthium*), Euphorbiaceae (*Mercurialis annua*, *M. elliptica*, *M. tomentosa*), Leguminosae (*Coronilla*, *Lotus*, *Medicago*), Poaceae (*Poa*, *Avena*, *Vulpia*, *Hordeum*, *Brachypodium*, *Gaudinia*, *Bromus*, *Dactylis*, *Lolium*, *Panicum*, *Trisetaria*, *Piptatherum*, *Stipa*, *Aegilops*, *Phalaris*, *Melica*, *Agrostis*, *Holcus*, *Paspalum*,

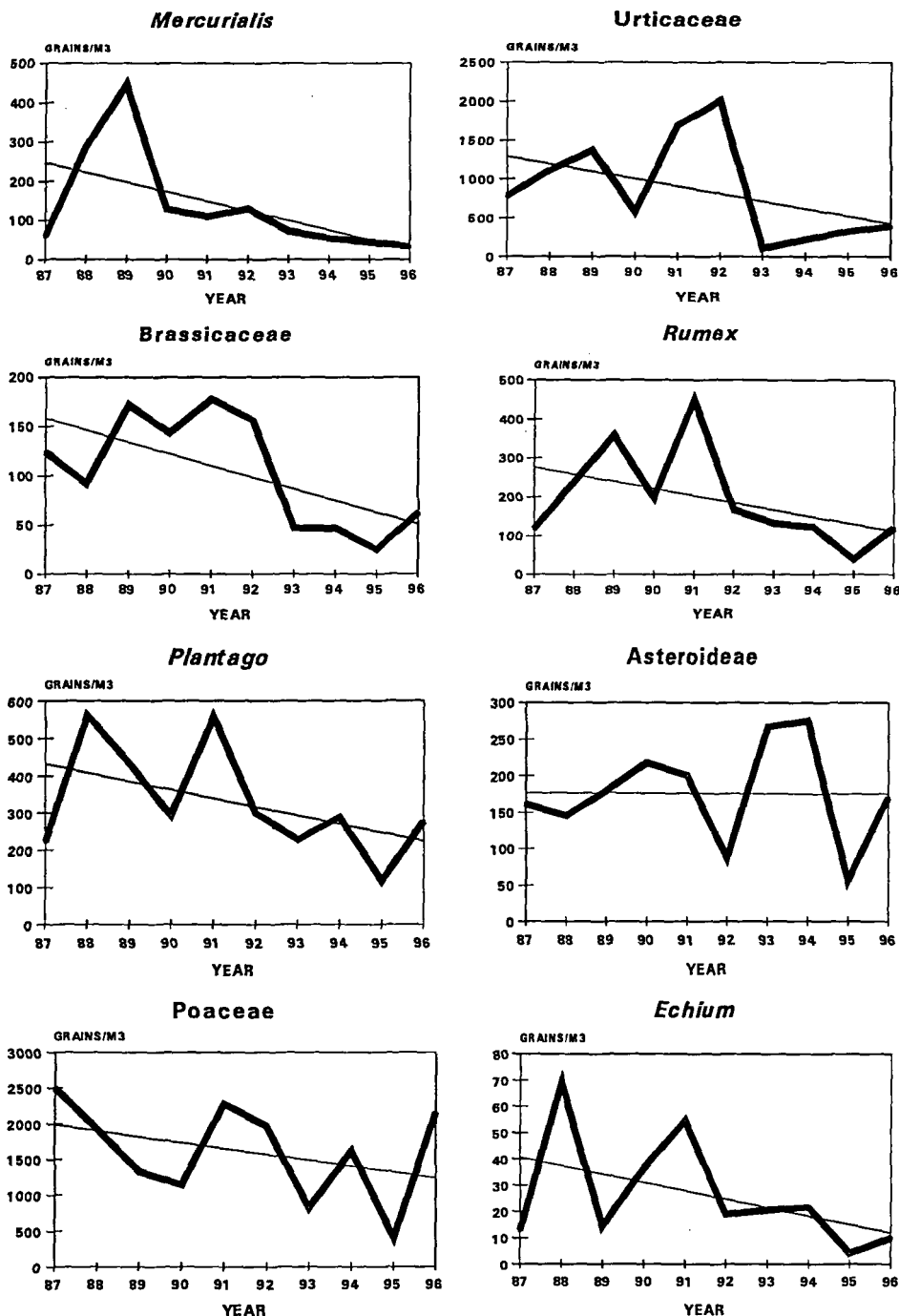


Fig. 1. Variation, over the years, and trends in annual total concentrations (grains/m³) of the non-arboreal types studied.

Echinocloa, *Cynodon*, *Hyparrhenia*), Plantaginaceae (*Plantago coronopus*, *P. lagopus*, *P. lanceolata*), Polygonaceae (*Rumex bucephalophorus*, *R. tingitanus*, *R. acetosella*, *R. angiocarpus*) and Urticaceae (*Urtica urens*, *U. dioica*, *U. membranacea*, *Parietaria judaica*, *P. mauritanica*) (Valdés et al. 1987a).

The halophyte communities are found on salt-marshes flooded periodically by sea-water, located to the south-east of the city (on the Guadalquivir estuary). These wetlands occupy 95,000 hectares. They are abundant in

Chenopodiaceae, which are very resistant to the high concentrations of sodium chloride, (*Salicornia*, *Sarcocornia*, *Salsola*, *Suaeda*, *Arthrocnemum*, *Chenopodium*, *Beta*), and some Gramineae (*Stipa*, *Phalaris*, etc.). The marsh communities comprise Poaceae, Typhaceae (*Typha angustifolia*, *T. domingensis*, *T. latifolia*) and Cyperaceae (*Cyperus*, *Carex*), which colonize the banks of the slowly flowing watercourses and the fresh water lagoons. These areas, which in other times were abundant, are today under great pressure from agriculture, and are being turned into cropland.

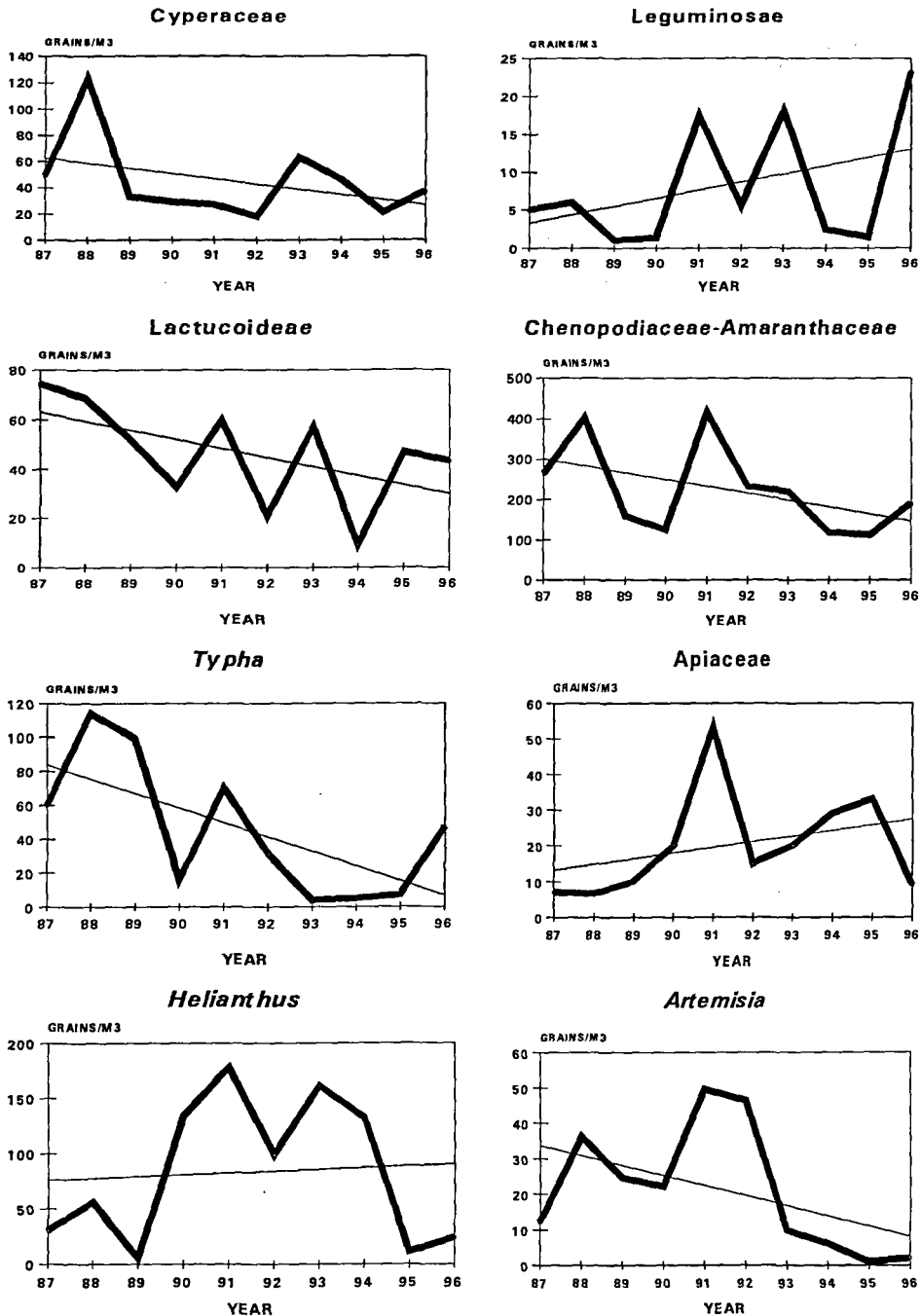


Fig. 1. Continued.

Crops occupy a large part of the region: the growing of various non-arboreal plants (together with the olive) is the main economic activity. The most important crops are dry-farming cereals (*Triticum*, *Secale*, *Hordeum*), sunflower (*Helianthus annuus*), sugar beet (*Beta vulgaris*), legumes (*Medicago sativa*, *Trifolium*), rice (*Oryza sativa*), maize (*Zea mays*) cotton (*Gossypium*).

MATERIAL AND METHODS

The study was carried out with a Cour trap installed on the roof terrace of the School of Pharmacy, Seville University, at 15 metres

above ground level. The site was not shielded, but exposed to the prevailing wind. The trap functioned continuously for 10 consecutive years (1987–1996). Samples were taken each Monday, giving 522 samples.

The Cour trap was designed in 1973 (Cour 1974). It consists of two vertical filters supported on a rod 3 metres above ground level. The filters are protected from the rain, and continuously face into the wind under the action of a vane fitted to the back of the device. The device does not need electrical power: the particles found in the air are pushed by the wind into the mesh of the filters. Each filter consists of five sterile gauzes overlaid in the form of a net and fitted into a plastic frame, giving a surface area of 400 cm². The filters are normally exposed for a week, although they can be changed two or

three times weekly if, for example, the aim is to make crop prediction studies.

For the chemical treatment of the filters and the microscopic analysis of the preparations, at least two days are needed. The two procedures can be summed up in five stages:

- The gauze is dissolved and the sand and organic particles retained with the pollen are removed. This is achieved with successive treatment of sulphuric acid, 70% hydrofluoric acid and hydrochloric acid.
- The resulting pollen is acetolyzed and coloured with basic fuchsin.
- The volume of pollen collected is quantified. This operation is carried out by adding a known volume of glycerine and collecting the resulting volume (pollen + glycerine) with a micropipette.
- A large part of the total recovered pollen will be read. For this purpose, the microscopic preparations are mounted in 50 μ l aliquots of the above volume.
- Both the amount and diversity of the pollen collected on the filter are determined microscopically. The wind speed is known from a totalizing anemometer located beside the sampler, so that the pollen count from the analysis can be expressed as grains/ m^3 of air.

Further information on the Cour method can be obtained from the following works: Bousquet et al. (1984), Richard (1985), Rizzi Longo & Cristofolini (1987), Meinren (1988), Belmonte & Roure (1991, 1995), González Minero & Candau (1997), Tomás et al. (1997).

The microscopic identification of the pollen types was based on the work of Valdés et al. (1987b).

The meteorological data (annual mean temperature and annual total precipitation) were obtained from the information supplied by the station of the National Meteorological Institute in María Luisa Park, 1 km from the pollen trap as the crow flies.

The work also includes agronomic data on the variation, over the study years, of the areas of the most important non-arboreal crops in the province of Seville. These data were obtained from the Consejería de Agricultura (Board of Agriculture) of the Andalusian regional government.

Finally, the study was made on those non-arboreal types which exceeded 0.05% of the total pollen collected over the ten years.

RESULTS

Weather conditions, crop areas, and annual pollen concentrations, 1987–1996

A review of the annual total amounts of pollen of the non-arboreal types studied (Fig. 1) must take into account the climatology during the years of sampling. Table I shows the values of annual mean temperature and annual total precipitation recorded during the years studied.

Table I. Annual mean temperatures and annual total precipitation recorded during the years studied.

Year	Mean Temp. (°C)	Rainfall (mm)
1987	18.7	656
1988	18.6	531
1989	19.4	982
1990	19.6	406
1991	18.7	531
1992	18.5	358
1993	18.2	309
1994	19.6	303
1995	20.4	502
1996	19.3	892

itation recorded from 1987 to 1996. The outstanding climatological feature of that period is the drought of 1990 to 1995, when, for six consecutive years, annual total precipitation did not reach 600 mm. This situation was particularly severe in the three-year period 1993–95, when the lack of precipitation was aggravated by annual mean temperatures much higher than the mean of 18.8°C (19.6°C in 1994 and 20.41°C in 1995).

The graphs of Fig. 1 show the negative trend, over the years, in 12 of the 16 taxa studied. This negative trend is a consequence of the small amounts of pollen collected in the period 93–95 (and especially in 1995). No negative trend was observed in Apiaceae, Leguminosae, Asteroideae and *Helianthus*.

Fig. 2 shows the variation over the years in the areas of the most important non-arboreal crops in the province of Seville. The most significant aspects of the figure are the following:

- The dry-farming cereals (which includes wheat, oats, barley, rye, and triticale) and sunflower are the two most-abundant crops, with normally an annual area exceeding 200,000 hectares respectively.
- During the period 1987–1991, a larger area was dedicated to the four herbaceous crops (cereals, sunflower, beet, and green vegetables) than in 1992–1996. During this latter period, the area given over to cereals fell to below 300,000 hectares, that to sunflower fell from 600,459 hectares in 1991 to 174,300 hectares in 1994, beet fell from 59,507 hectares in 1991 to 19,610 hectares in 1996, and green vegetables fell from 4500 hectares in 1991 to 1000 hectares in 1995 and 1996.

At the same time, we have related the variation over the years of the areas dedicated to these four crops with the variation over the years of the annual total pollen concentrations of Poaceae, *Helianthus*, Chenopodiaceae-Amaranthaceae and Leguminosae. The results show a statistically significant direct correlation for area/pollen in the case of the main crops: Poaceae ($r^2=0.537$, $r=0.733$, $p=0.016$) and *Helianthus* ($r^2=0.475$, $r=0.689$, $p=0.027$), and a non-significant negative relationship in Chenopodiaceae-

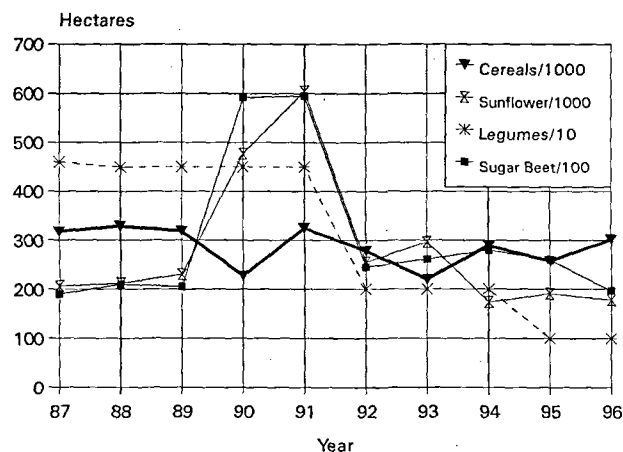


Fig. 2. Variation, over the years, in the areas of the most important non-arboreal crops of the province of Seville.

Amaranthaceae ($r^2=0.152$, $r=-0.232$, $p=0.674$) and Leguminosae ($r^2=0.080$, $r=-0.283$, $p=0.428$).

Quantitative and qualitative importance of non-arboreal pollen in the pollen spectrum. Non-arboreal pollen curves

Of the total pollen collected, 22.34% is non-arboreal. This is a mean value for the set of the ten years of study, given that the amount in the spectrum varies from year to year. In general terms, in the years 1987–1991, grass pollen exceeded 30% of the total non-arboreal pollen collected, with 1990 having the maximum at 41.51%. In 1992–1996, the amount of grass pollen was always less than 30% of total pollen collected, with 1995 having the minimum of 22%. From a study of the percentages of representation of the non-arboreal types in the total pollen collected (mean values of the ten years of study), these types can be grouped in three classes:

- Main herbaceous types, with a representation greater than 1%: Poaceae (9.12%), Urticaceae (4.07%), *Plantago* (1.92%), Chenopodiaceae-Amaranthaceae (1.33%), Asteroideae (1.16%), and *Rumex* (1.07%).
- Types with a representation of between 0.5 and 1%: *Mercurialis* (0.74%), Brassicaceae (0.55%), and *Helianthus* (0.53%).
- Minor types, with a representation lower than 0.5%: Lactucoeae (0.32%), Cyperaceae (0.30%), *Typha* (0.24%), Apiaceae (0.17%), *Echium* (0.16%), *Artemisia* (0.10%), and Leguminosae (0.06%).

Fig. 3 shows the variation, through the year, in the weekly pollen concentrations of the pollen types studied. The pollen types are listed by starting date of the main pollination period (Pathirane 1975). The graphical visualization has been improved by adapting the weekly concentrations to the semi-quantitative scale proposed by Spieksma (1991). The types are listed in order of the starting date of the main pollination period. The values are means of the results from the 10 years of sampling.

The appearance of airborne non-arboreal pollen can be summarized as the following: *Mercurialis* and Urticaceae appear in January; Brassicaceae and *Rumex* in February; *Plantago*, Asteroideae, Poaceae and *Echium* in March; Cyperaceae, Leguminosae, Lactucoeae, and Chenopodiaceae-Amaranthaceae in April; *Typha* in May; Apiaceae and *Helianthus* in June; and *Artemisia* in October.

The main pollination periods lasted longer than 15 weeks, except for *Artemisia* and *Helianthus*. The longest were those of Brassicaceae and Poaceae (more than 25 weeks in each case).

The pollen curve (the variation, through the year, in the weekly pollen concentration) could be one of three types: very prolonged through the year, with numerous rises and falls in the weekly concentrations (Urticaceae, Poaceae, Chenopodiaceae-Amaranthaceae); less prolonged through the year, also with numerous rises and falls in concentration, but with lower weekly concentrations than in the former case (*Plantago*, *Rumex*, Asteroideae, Brassicaceae and *Mercurialis*); and shorter, more intense curves, with intermittent pollen appearance and very low weekly pollen concentra-

tions (*Echium*, Cyperaceae, Leguminosae, Lactucoeae, *Typha*, Apiaceae, *Helianthus*, *Artemisia*), see Fig. 3.

DISCUSSION

The climatology of the study period, which included a prolonged drought that began in 1990 and reached its severest moment in 1995, undoubtedly had an effect in the negative trend found in the variation of annual total concentrations of many non-arboreal types. Thus, 1995 was the year of minimum pollen collection for Brassicaceae, *Rumex*, *Plantago*, Asteroideae, Poaceae, *Echium*, Cyperaceae, Leguminosae, *Helianthus*, and *Artemisia* (Fig. 1). This illustrates the negative effect the absence of precipitation has on the amount of non-arboreal pollen collected. Similar phenomena were found for Poaceae by Subiza et al. (1991) and for Urticaceae by Roure & Belmonte (1987), Subiza et al. (1991), and Emberlin & Norris-Hill (1991). However, other factors may play a role. Such is the case of Urticaceae, which showed a drastic fall in the annual pollen from 1993 (Fig. 1). This reduction coincided with the end of the 1992 Universal Exposition in Seville, which had caused a profound transformation in the urban landscape of the city, with the disappearance of many wasteland sites that were built upon or turned into parks. The disappearance of these large, abandoned, nitrogenated areas could well be another cause of the decrease in Urticaceae pollen.

Nevertheless, drought can favour the airborne presence of other pollen types, especially entomophilous ones, which, as a result of the dryness of the air and the absence of precipitation, increase their concentrations in dry years; this could be the case of Apiaceae and Asteroideae (Fig. 1).

The drought was undoubtedly the cause of the reduction in the area of the most important crops, especially those under irrigation, such as beet and green vegetables. The statistically significant ratio of pollen/area in the main crops (dry-farming cereals and sunflower) is particularly interesting, and is an example of how certain agricultural practices are related with the pollen spectrum. In the case of the Poaceae, the sowing of cereals (cultivated Poaceae) is related with the collection of the pollen type Poaceae (comprising mainly pollen from wild species). This suggests that wild and dry-farmed Poaceae are subject to the same phenological conditioners regarding rainfall. This situation can be used to estimate the intensity of the pollen season of the Poaceae before it starts, as in this zone, cereal sowing takes place in February, and the pollen season of the Poaceae begins in the second half of April. A similar relationship has been described in Madrid by Subiza et al. (1991).

The non-arboreal vegetation of the region is also represented in the airborne pollen content. It must be remembered that Seville is a great centre of population, with a strongly anthropogenized environment (many abandoned wasteland sites and intensive agriculture). It is therefore coherent that the best-represented types in the pollen spectrum are Poaceae, Urticaceae, Plantaginaceae, Amaranthaceae and Chenopodiaceae, Compositae, Brassicaceae, and Apiaceae.

The percentages of representation of Chenopodiaceae-Amaranthaceae (the fourth most important type) and of *Typha* and Cyperaceae are indicators of the importance of

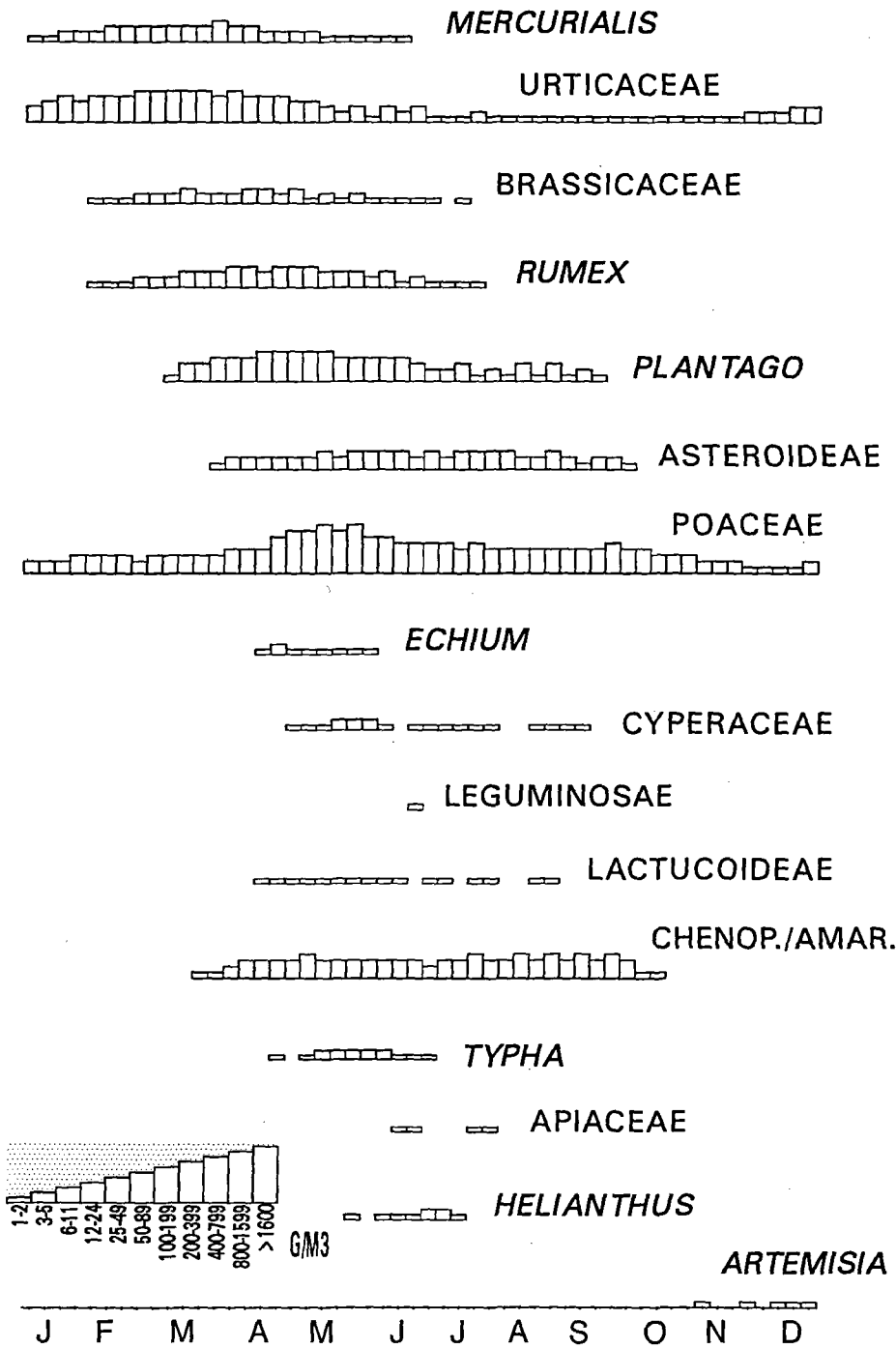


Fig. 3. Variation, through the year, in weekly pollen concentrations (grains/m³) the non-arboreal types studied. Mean values for the period 1987–96.

the halophyte and marsh vegetation in the natural medium under study. The high representation of Chenopodiaceae-Amaranthaceae is a reflection of the abundant marshlands situated to the SW. At the same time, the low representation of *Typha* and Cyperaceae is evidence of the disappearance and transformation into agricultural land (especially in periods of drought) of the ecological habitat of marshland types.

The dynamics of the variation, through the year, in the weekly pollen concentrations of non-arboreal types (Fig. 3) do not differ from what has been reported for other Mediterranean regions of southern Europe (Spieksma 1991).

Taxa appear in the air from the beginning of the year (*Urticaceae* and *Mercurialis*), generally remain in the air for many weeks, with prolonged main pollination periods and numerous rises and falls in pollen concentration as a consequence of the stepped flowering through the year of the numerous species making up the pollen types. The highest concentrations are found in May, before the climatic rigours of the southern Spanish summer (total absence of precipitation and extremely high mean temperatures) wither most of the non-arboreal plants. That month sees the peaks of *Poaceae*, *Plantago*, *Asteroideae*, and *Rumex*, and the greatest airborne

pollen diversity, resulting from the coincidence in the air of most of the types studied. Before May, high winter concentrations of Urticaceae are recorded (due mostly to the flowering of *Urtica*, since *Parietaria* is very scarce). Later, the summer collection shows low concentrations of *Helianthus annuus* from pollen reffotation during sunflower harvesting (Candau et al. 1994); moderate amounts of Poaceae (possibly from halophyte Gramineae with summer flowering); and Chenopodiaceae/Amaranthaceae, present in the air from many months earlier, although it is in summer that the halophyte representatives of the Chenopodiaceae flower.

CONCLUSIONS

The results presented give a good idea of the behaviour of non-arboreal pollen collected in the air of Seville through the year and over the years. The 10 years of observations constitute a reasonably long period of results, and include a drought, which is a frequent climatological feature of the Mediterranean area.

The non-arboreal pollen spectrum of Seville is a reflection of the non-arboreal vegetation and of the agricultural practices of the region. The spectrum is dominated by Poaceae, Urticaceae, *Plantago*, and Chenopodiaceae-Amaranthaceae, but entomophilous pollen also appears (Brassicaceae, *Helianthus*, Leguminosae, Asteroideae, and Lactucoeidae), and in some cases is more abundant than anemophilous pollen (*Artemisia*, Cyperaceae and *Typha*).

The variation in annual total concentration over the years indicates how a period of drought can affect the pollen composition of the air: it increases the amount of some pollen types directly, such as in the entomophilous Apiaceae, Leguminosae and sunflower.

In Seville, the presence of airborne non-arboreal pollen is stepped during the first six months of the year. Some types remain in the air for many months (Poaceae, Urticaceae, Chenopodiaceae, *Plantago*, and *Rumex*). The highest concentrations are recorded at three moments of the year: March (Urticaceae), May (Poaceae, *Plantago*, *Rumex*, and Chenopodiaceae-Amaranthaceae), and August (Chenopodiaceae-Amaranthaceae).

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