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AIRBORNE POLLEN OF *CARYA*, *CELTIS*, *CUPRESSUS*, *FRAXINUS* AND *PINUS* IN THE METROPOLITAN AREA OF MONTERREY NUEVO LEON, MEXICO

Alejandra Rocha-Estrada, Marco Antonio Alvarado-Vázquez, Teresa Elizabeth Torres-Cepeda, Rahim Foroughbakhch-Pournavab, Jorge Luis Hernández-Piñero

Departamento de Botánica, Facultad de Ciencias Biológicas, San Nicolás de los Garza, Nuevo León, México

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Abstract: The concentration of pollen grains in the atmosphere over the metropolitan area of Monterrey, Nuevo Leon, Mexico, was analyzed throughout a year from March 2003–February 2004, focused on the genus *Carya, Celtis, Cupressus, Fraxinus* and *Pinus* owing to their interest as etiological pollinosis agents in diverse regions of the world. A 7-day Hirst type volumetric spore and pollen trap was located on a building roof of the city at 15 m from ground level for continuous sampling. The total quantity of pollen recorded for the study period was 21,083 grains/m^3, corresponding to 49.75% of the taxa of interest. February and March were the months with higher pollen amounts in the air with 7,525 and 2,781 grains/m^3, respectively, and amounted to 49% of total year through pollen. *Fraxinus* was the genus which contributed to the largest amount of pollen with 28% of total grains (5,935 grains/m^3) followed by *Cupressus* with 13% (2,742 grains/m^3). *Celtis*, *Pinus* and *Carya* contributed with 5.3%, 2.7%, and 0.6% of total pollen, respectively. These results indicate that *Fraxinus* and *Cupressus* are present in the area in sufficient quantity to indicate likely involvement in the origin of allergic disorders in the human population.

Address for correspondence: Alejandra Rocha-Estrada, Departamento de Botánica, Facultad de Ciencias Biológicas, Apartado Postal 38 F, Ciudad Universitaria, C.P. 66450, San Nicolás de los Garza, Nuevo León, México. E-mail: arochaestrada@gmail.com

Key words: airborne, pollen, *Carya, Celtis, Cupressus, Fraxinus, Pinus*, Monterrey, México.

INTRODUCTION

Pollen grains are the masculine sex cells of flowering plants which are formed inside stamens and released into the air once they are mature. Their biological function is to reach the feminine part of a flower of the same species and to make possible the fertilization of ovules [6]. The existence of pollen grains in the atmosphere is a natural phenomenon occurring as a result of the sex cycle of anemophilous plants. The dispersion of such pollen grains is a dynamic event governed by meteorological phenomena which influence the mechanisms of emission, transport, permanence, deposition and capture of the grains [36]. *Carya, Celtis, Cupressus, Fraxinus* and *Pinus* are very abundant plants in the metropolitan area of Monterrey, frequently used as ornate plants in gardens and public parks, streets, avenues, sidewalks and private gardens [3, 28, 29]. Nevertheless, according to diverse studies it has been recognized that the species of these genus are etiological agents of pollinosis in diverse places all over the world [14, 19, 22, 23, 26, 31, 35, 37].

Owing to the interest concerning the participation of pollen grains in seasonal allergic rhinitis episodes, the pollen concentration in the air of the metropolitan area of Monterrey from the taxa above mentioned was studied in order to obtain useful data for the prevention and diagnosis of diseases caused by the inhalation of these pollen grains.

MATERIALS AND METHODS

Area of study. The metropolitan area of Monterrey is located in the Mid-West part of the Nuevo Leon State, Mexico, in the physiographic provinces of the Coastal Plain

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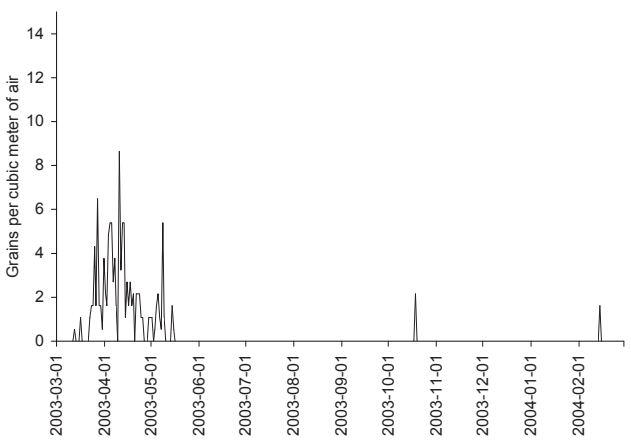

Figure 1. Average daily concentrations of *Carya* pollen (grains/m^3).

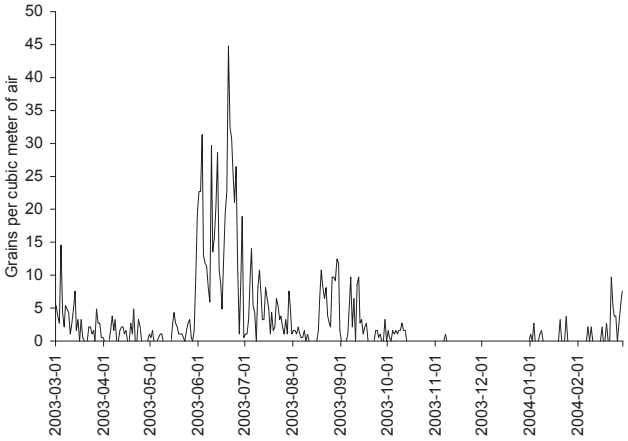

Figure 2. Average daily concentrations of *Celtis* pollen (grains/m^3).

of the North Gulf and the Sierra Madre Mountain range, which includes the municipalities of Apodaca, Escobedo, Guadalupe, Monterrey, Santa Catarina, San Nicolás de los Garza, and San Pedro Garza García, which altogether comprise an approximate area of 1,480 km^2, located between the parallels 25°35′ and 25°50′ North latitude, and between the meridians 99°59′ and 100°30′ West longitude, to an altitude of 540 (between 400-800) m.a.s.l. [7].

The climate characteristic according to the classification system of Köeppen modified by García [11], correspond to dry warm and extreme steppe, with irregular rains at the end of summer [-BS(h')hw(é)] and an annual average temperature of 22.1°C. Precipitation is scarce, between 300–500 mm. The prevailing winds in the region come from the Northeast and Southeast, which are more intense in the warmer half of the year [21].

Trees, shrubs, herbs and palms are the main components of the urban flora in the study area, which are cultivated in the streets, avenues and parks of the city. The main species present are *Fraxinus* spp., *Ficus benjamina*, *Ligustrum lucidum*, *Melia azederach*, *Platanus occidentalis*, *Quercus* spp., *Pinus* spp., *Cupressus* spp., *Acacia farnesiana*, *A. rigidula*, *Phitecellobium dulce*, *Morus* spp., *Tamarindus indicus*, *Punica granatum*, *Salix* spp., *Populus* spp., *Jacaranda mimosifolia*, *Nerium oleander*, *Amaranthus* spp., *Washingtonia* spp., *Yucca* spp., *Ricinus communis* [3, 29].

POLLEN SAMPLING AND COUNTS

The aerobiological sampling was made throughout a year from March 2003–February 2004. Recommendations from the Pan-American Aerobiology Association [30] for sampling of anemophilous pollen were taken into account. A Hirst type volumetric spore trap (Burkard Manufacturing Co, Rickmansworth, Herts., UK) was located on the roof of the main building of the Faculty of Biological Sciences of the Universidad Autónoma de Nuevo Leon, about 15 m above ground level and elevated 1 m from the ceiling. A Melinex tape of 345 mm covered with sticky silicone oil was prepared and placed in the rotary drum of the equipment. After the apparatus is turned on a constant air flow of 10 l/min penetrates through an orifice of 2 mm × 14 mm, and the entering pollen grains stick to the tape, which is moving at a speed of 2 mm/hr for a complete cycle of 7 days. The sampling tape was changed weekly and carefully transported to the laboratory for processing and analysis.

The tape was divided in 7 segments, each one of 48 mm in length, corresponding to each sampling day, and adhered to standard glass slides covered with gelatin-glycerin and stained with basic fuchsin. For taxa identification the works of Kremp [18], Erdtman [8, 9], Faegri and Iversen [10], and Kapp *et al.* [17] were used. In addition, comparisons of the obtained pollens samples were made with reference

Table 1. Month and total sum of the daily pollen values, expressed as grains/m^3 of air.

Taxa	Mar	Apr	May	Jun	Jul	Agus	Sep	Oct	Nov	Dic	Jan	Feb	Total
Carya	26	73	16					2				2	118
Celtis	91	34	59	536	140	116	63	17	1		14	48	1,118
Cupressus	99	30	1					163	59	504	1,627	259	2,742
Fraxinus	224	14	3	4							438	5,253	5,935
Pinus	72	256	172	5		1		1	8	5	7	51	577
Others	2,270	1,300	479	647	670	753	683	1,060	364	227	226	1,913	10,592
Total	2,781	1,706	729	1,192	811	870	746	1,243	432	736	2,311	7,525	21,083

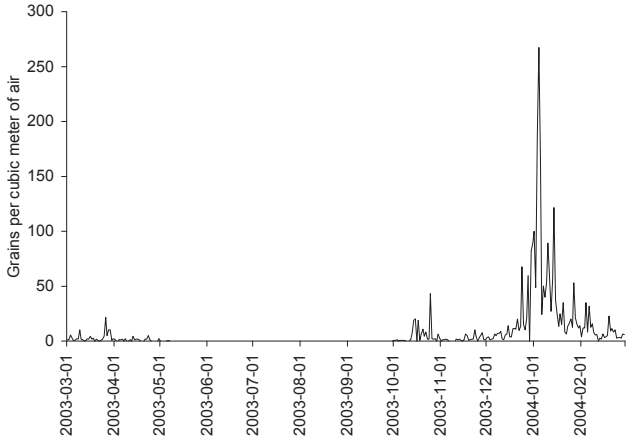

Figure 3. Average daily concentrations of *Cupressus* pollen (grains/m^3).

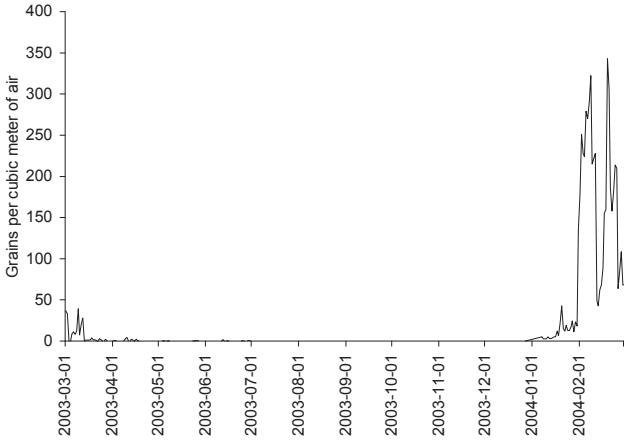

Figure 4. Average daily concentrations of *Fraxinus* pollen (grains/m^3).

specimens elaborated for this effect with grains of pollen collected from the species belonging to the vegetation of the study area. The total pollen concentration was determined per day as well as the number of grains from each taxa per air volume. In each glass slide, 4 longitudinal scans were made under the optical microscope using a 400× objective lens. The obtained results of the count per glass slide were converted to values of density per air volume by multiplying the values by a correction factor of 0.54 to obtain the total number of grains per cubic meter of air.

RESULTS AND DISCUSSION

A total of 21,083 grains/m^3 of air was registered in the period from March 2003–February 2004 for the area of study, of which 10,491 grains/m^3 (49.75%) corresponds to pollen from the taxa *Carya*, *Celtis*, *Cupressus*, *Fraxinus* and *Pinus*; while the remaining 10,592 grains/m^3 corresponded to other trees, shrubs and weeds. The months of maximum pollen concentration were March 2003 (2,781 grains/m^3) and February 2004 (7,525 grains/m^3) when 48.88% of the total pollen was obtained (Tab. 1).

The *Carya* species reported in the study area correspond to *C. cordiformis* (Wangenh.) K. Koch and *C. illionensis* (Wangenh.) K. Koch [2]. The pollen concentration of *Carya* was 118 grains/m^3 of air, representing 0.56% of total pollen. Pollen from this taxon was present during the months of March–May, October and February, reaching maximum values in the month of April with 73 grains/m^3, with a maximum daily average concentration of 9 grains/m^3 registered on 10 April (Fig. 1). These results are similar to those obtained in Israel where there is a well defined pollen season from mid April–May [27]. On the other hand, in North America pollen from this species is considered as an important cause of allergic rhinitis. It has been also reported that in Israel it constitutes a possible etiological agent for the development of the asthma in children [24, 27, 33].

The *Celtis* species most abundant in the metropolitan area of Monterrey are *C. laevigata* Willd. and *C. pallida* Torr. [2, 29]. The registry of total pollen for *Celtis* spp. was 1,118 grains/m^3 of air (5.30%). These grains were present throughout the whole period of study except during the month of December, reaching its maximum monthly concentration in June with 536 grains/m^3, and a mean maximum day concentration on 20 June with 45 grains/m^3 of air (Fig. 2). *Celtis* genus anemophily has been reported in Italy, United States and Argentine [12, 20, 24, 32, 34].

The registered species for the genus *Cupressus* in the study area were *C. arizonica* Greene (white cedar) and *C. sempervirens* L. (column cypress) [2, 29]. The pollen concentration of *Cupressus* spp. was 2,742 grains/m^3 of air, representing 13% of the total pollen. This taxon reached its maximum monthly concentration in January (1,627 grains/m^3) with a maximum daily average of 267 grains/m^3 4 January (Fig. 3). Similar results were registered in Santiago de Compostela (Spain), where the maximum levels of this pollen were recorded from December–April, reaching peaks between January–March [1], whereas to the southwest of Sydney (Australia) counts superior to 1,000 grains/m^3 of air were reported, with a maximum daily average of 1,842 grains/m^3 during the second week of October [5].

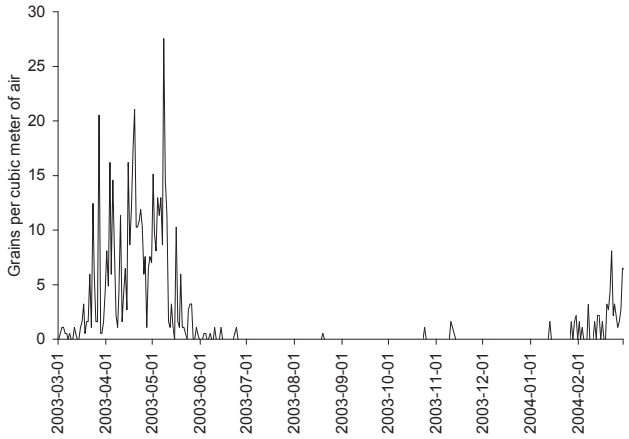

Figure 5. Average daily concentrations of *Pinus* pollen (grains/m^3).

The species of the genus *Fraxinus* occurring in the metropolitan area of Monterrey were *F. americana* L., *F. berlandieriana* A.DC., *F. cuspidata* Torr., *F. greggii* A. Gray y F. uhdei (Wenz.) Lingel [2]. The sum of the concentrations of pollen from *Fraxinus* spp. during the period of study was 5,935 grains/m^3 of air (28.15%), with February being the month with the greatest concentration of 5,253.12 grains/m^3, not registering pollen presence in the months from July–December. The average daily maximum concentration was of 343 grains/m^3 of air on 19 February (Fig. 4). Horak *et al.* [1980, cited by Peeters, 25] consider that for this taxon the daily average of 167 grains/m^3 of air are a critical concentration concerning the appearance of allergic symptoms in humans. On the other hand, Weryszko-Chmielewska and Piotrowska [37] registered main periods of pollination lasting between 17–28 days (2001 and 2002), and with maximum daily concentrations of 143 and 287 grains/m^3 of air in Lublin (Poland), whereas concentration peaks between 23–837 grains/m^3 were counted in Vienna (Austria) [14]. Anemophily of the *Fraxinus* genus has been observed in France, Hungary, Argentine, Spain, Switzerland and Austria [12, 14, 15, 19, 23, 25].

The *Pinus* species reported in the study area are *P. cembroides* Zucc, *P. greggii* Engelm., *P. halepensis* Mill., *P. heldarica* Medw and *P. pseudotrobus* Lindl. [2, 29]. The total concentration of *Pinus* spp. pollen during the period of study was 577 grains/m^3 of air, representing approximately 2.73% of the total of pollen registered. The monthly maximum concentrations were recorded during April (256 grains/m^3) and May (172 grains/m^3), with the maximum daily average concentration reached on 8 May with 28 grains/m^3 of air (Fig. 5). This daily average concentration is relatively low in comparison with the registered values for Ciudad de la Plata (Argentine), Vigo (Spain) and Brisbane (Australia) where daily average concentrations of 2,028, 1,105 and 158 grains/m^3 of air have been registered respectively [13, 16, 23]. On the other hand, Levetin *et al.* [20] have reported an annual total concentration for *Pinus* pollen of 1,246 grains/m^3 of air in Tulsa (United States), whereas for Bilbao (Spain) a total concentration of 6,118 grains/m^3 of air was registered [4], which are values noticeably higher to those found in the present study. Although the allergenic effects of pollen from the *Pinus* genus have been documented in diverse studies, high controversy still remains about the accuracy of this statement [1, 4, 22].

CONCLUSIONS

The total amount of pollen registered for the metropolitan area of Monterrey was 21,083 grains/m^3, of which 10,491 grains/m^3 (49.75%) correspond to *Carya*, *Celtis*, *Cupressus*, *Fraxinus* and *Pinus*. The months of maximum pollen concentration were March and February when 48.88% of the total pollen grains were obtained. Pollen from *Cupressus* and *Fraxinus* reached the highest total concentrations during the period of study, whereas *Carya* and *Pinus* presented the lowest total concentration. *Fraxinus* and *Cupressus* were the taxa with the highest maximum daily concentrations with 343 and 267 grains/m^3, respectively. The pollen concentration values registered for *Fraxinus* and *Cupressus* in the metropolitan area of Monterrey during the period of study showed a high probability of being causative agents of allergic disorders in the population, whereas the three remaining taxa showed concentrations in amounts with a smaller probability of causing these disorders. However, studies with longer periods of sampling time are recommended to evaluate the aerobiological behaviour of these taxa in order to have more precise and reliable data.

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REFERENCES

1. Aira MJ, Dopazo A, Jato MV: Aerobiological monitoring of Cupressaceae pollen in Santiago de Compostela (NW Iberian Peninsula) over six years. *Aerobiologia* 2001, **17**, 319-325.

2. Alanís-Flores G, González-Alanís D: Flora urbana del área metropolitana de Monterrey, Nuevo León, México. **In:** Galán Wong LJ, Olvera HA, García Salas JA, Arévalo Niño K, Cavazos Leal A, Pereyra Alférez B (Eds): *Alba y Horizonte*, 1-16. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México 2002.

3. Alanís-Flores G, Foroughbakhch-Pornavab R, Alvarado-Vázquez MA, Rocha-Estrada A: El arbolado urbano en el área metropolitana de Monterrey (AMM), Nuevo León, México. *Arborea* 2004, **11**, 14-26.

4. Antepara I, Fernández-Martínez JC, Jáuregui I, Egusquiaguirre C, Fernández-Galdeano L, Gamboa PM: Estudio de la polinización en el área de Bilbao en 1995. Actualización de los estudios de sensibilizaciones a pólenes en la población. *Rev Esp Alergol Inmunol Clin* 1998, **13(2)**, 71-76.

5. Bass D, Morgan G: A three year (1993-1995) calendar of pollen and Alternaria mould in the atmosphere of south-western Sydney. *Grana* 1997, **36**, 293-300.

6. Belmonte-Soler J, Roure-Nolla JM: Introducción. **In:** Valero-Santiago AL, Cadahia-García A (Eds): *Polinosis, Polen y Alergia*, 7-16. MRA ediciones, España 2002.

7. Cervantes-Borja J, Merla-Rodríguez G: Geografía del valle de Monterrey. **In:** Garza Villarreal G (Eds): *Atlas de Monterrey*, 27-32. Gobierno del Estado de Nuevo León, Universidad Autónoma de Nuevo León, Instituto de Estudios Urbanos de Nuevo León, El Colegio de México, México 1995.

8. Erdtman G: *Pollen and Spore Morphology/Plant Taxonomy. Gymnospermae, Pteridophyta, Bryophyta (An Introduction to Palinology II)*. Alquimist and Wirksell/Stockholm, The Ronald Press Company, New York 1957.

9. Erdtman G: *Pollen Morphology and Plant Taxonomy (An Introduction to Palinology I, Angiosperms)*. Hafner Publishing Company, New York and London 1966.

10. Faegri K, Iversen J: *Text Book of Pollen Analysis*. The Blackburn Press, Denmark, 1989.

11. García E: *Modificaciones al Sistema de Clasificación Climática de Köppen*. Instituto de Geografía, Universidad Nacional Autónoma de México, México 2004.

12. Gattuso S, Gattuso M, Lusardi M, Mc Cargo J, Scandizzi A, Cortadi A, Ardusso LRF, Crisci CD: Polen aéreo, monitoreo diario volumétrico en la ciudad de Rosario. Parte I: árboles y arbustos. *Arch Alergia Inmunol Clin* 2003, **34**, 22-27.

13. Green BJ, Yli-Panula E, Dettmann M, Rutherford S, Simpson R: Airborne *Pinus* pollen in the atmosphere of Brisbane, Australia and relationships with meteorological parameters. *Aerobiologia* 2004, **19**, 47-55.

14. Hemmer W, Focke M, Wantke F, Gotz M, Jarish R, Jager S, Gotz M: Ash (*Fraxinus excelsior*) pollen allergy in central Europe: specific role of pollen allergens and the major allergen of ash pollen, Fra e 1. *Allergy* 2000, **55(10)**, 923-930.

15. Jarai-Komlodi M: First results of a study on airborne sporomorphs in Budapest, Hungary. *Grana* 1991, **30**, 464-466.

16. Jato MV, Rodríguez FJ, Seijo MC: *Pinus* pollen in the atmosphere of Vigo and its relationship to meteorological factors. *Int J Biometeorol* 2004, **43(4)**, 147-153.

17. Kapp OR, Davis OK, King JE: *Pollen and Spores*. The American Association of Stratigraphics Palynologists Foundation Publication, USA 2000.

18. Kremp GOW: *Morphology Encyclopedia of Palinology*. The University of Arizona Press, Tucson, USA 1965.

19. Laurent J, Guinnepain MT, Sauvaget J, Lafay M: Allergic manifestations due to ash (*Fraxinus excelsior* L.) pollen in Paris. *Rev Fr Allergol Immunol Clin* 1998, **38(2)**, 89-93.

20. Levetin E, Rogers CA, Hall SA: Comparison of pollen sampling with a Burkard spore trap and a Tauber trap in warm temperate climate. *Grana* 2000, 39, 294-302.

21. Limón-Rodríguez B, Leal-Iga J: Climatología e Hidrología. **In:** Garza-Villarreal G (Ed): *Atlas de Monterrey*, 50-59. Gobierno del Estado de Nuevo León, Universidad Autónoma de Nuevo León, Instituto de Estudios Urbanos de Nuevo León, El Colegio de México, México 1995.

22. Marcos C, Rodríguez FJ, Luna I, Jato V, González R: Pinus pollen aerobiology and clinical sensitization in northwest Spain. *Ann Allergy Asthma Immunol* 2001, **87(1)**, 39-42.

23. Nitiu DS, Mallo AC: Incidence of allergenic pollen of *Acer* spp., *Fraxinus* spp. and *Platanus* spp. in the city of La Plata, Argentina: preliminary results. *Aerobiologia* 2002, **18**, 65-71.

24. Ogden CE, Raynor GS, Hayes JV, Lewis DM, Haines J: *Manual for Sampling Airborne Pollen*. Hafner Press a Division of Macmillan Publishing Inc. New York 1974.

25. Peeters AG: Frost periods and beginning of the ash (*Fraxinus excelsior* L.) pollen season in Basel (Switzerland). *Aerobiologia* 2000, **16**, 353-359.

26. Peternel R, Culig J, Mitic B, Vukusic I, Sostar Z: Analysis of airborne pollen concentrations in Zagreb, Croatia, 2002. *Ann Agric Environ Med* 2003, **10(1)**, 107-112.

27. Rachmiel M, Vergeler H, Waisel Y, Keynan N, Kivito S, Katz Y: The importance of the pecan tree pollen in allergic manifestations. *Clin Exp Allergy* 1996, **26**, 323-329.

28. Reséndiz-Infante CG: *Evaluación del arbolado urbano del municipio de Monterrey, N.L., México*. Tesis de Licenciatura, Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León, México 2003.

29. Rocha-Estrada A, Torres-Cepeda TE, González de la Rosa Ma del C, Martínez-Lozano SJ, Alvarado-Vázquez MA: Flora ornamental en plazas y jardines públicos del área metropolitana de Monterrey, México. *SIDA* 1998, **18(2)**, 579-586.

30. Rogers C, Muilenberg M: *Comprensive Guideline for the Operations of Hirs-type Suction Bioaerosol Sampler*. Pan-American Aerobiology Association. Standardized Protocols 2000

31. Sáenz de Rivas C: *Polen y esporas (introducción a la palinología y vocabulario palinológico), primera edición, H*. Blume Ediciones, Madrid 1978.

32. Smith EG: *Sampling and Identifying Allergenic Pollen and Molds*. Blewtone Press, San Antonio 1984.

33. Tejera L, Beri A: First volumetric airborne pollen sampling in Montevideo City, Uruguay. *Aerobiologia* 2005, **21**, 33-41.

34. Torri P, Accorsi CA, Bandini-Mazzanti M, Zagni AM: A study of airborne Ulmaceae pollen in Modena (northern Italy). *J Environ Pathol Toxic Oncol* 1997, **16(2-3)**, 227-230.

35. Valero-Santiago AL, Picado-Valles C: Polinosis. **In:** Valero-Santiago AL, Cadahia-García A (Eds): *Polinosis, Polen y Alergia*, 17-21. MRA ediciones, España 2002.

36. Vega-Maray AM, Valencia-Barrera RM, Fernández-González D., Fraile R: Urticaceae pollen concentrations in the atmosphere of north western Spain. *Ann Agric Environ Med* 2003, **10**, 249-255.

37. Weryszko-Chmielewska E, Piotrowska K: Airborne pollen calendar of Lublin, Poland. *Ann Agric Environ Med* 2004, **11(1)**, 91-97.