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, side-walks 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...
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 km², 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 indica, Punica granatum, Salix spp., Populus spp., Jacaranda mimostifolia, 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], Erdtmann [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.

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

**Figure 1.** Average daily concentrations of *Carya* pollen (grains/m³).

**Figure 2.** Average daily concentrations of *Celtis* pollen (grains/m³).
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/m³ of air was registered in the period from March 2003–February 2004 for the area of study, of which 10,491 grains/m³ (49.75%) corresponds to pollen from the taxa *Carya*, *Celtis*, *Cupressus*, *Fraxinus* and *Pinus*; while the remaining 10,592 grains/m³ corresponded to other trees, shrubs and weeds. The months of maximum pollen concentration were March 2003 (2,781 grains/m³) and February 2004 (7,525 grains/m³) 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. illinonensis* (Wangenh.) K. Koch [2]. The pollen concentration of *Carya* was 118 grains/m³ 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/m³, with a maximum daily average concentration of 9 grains/m³ 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/m³ 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/m³, and a mean maximum day concentration on 20 June with 45 grains/m³ 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/m³ of air, representing 13% of the total pollen. This taxon reached its maximum monthly concentration in January (1,627 grains/m³) with a maximum daily average of 267 grains/m³ 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/m³ of air were reported, with a maximum daily average of 1,842 grains/m³ during the second week of October [5].

![Figure 3. Average daily concentrations of Cupressus pollen (grains/m³).](image3)

![Figure 4. Average daily concentrations of Fraxinus pollen (grains/m³).](image4)

![Figure 5. Average daily concentrations of Pinus pollen (grains/m³).](image5)
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 and *F. uhdei* (Wenz.) Lingel [2]. The sum of the concentrations of pollen from *Fraxinus* spp. during the period of study was 5,935 grains/m³ of air (28.15%), with February being the month with the greatest concentration of 5,253.12 grains/m³, not registering pollen presence in the months from July–December. The average daily maximum concentration was of 343 grains/m³ 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/m³ 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/m³ of air in Lublin (Poland), whereas concentration peaks between 23–837 grains/m³ 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. pseudotobrus* Lindl. [2, 29]. The total concentration of *Pinus* spp. pollen during the period of study was 577 grains/m³ of air, representing approximately 2.73% of the total of pollen registered. The monthly maximum concentrations were recorded during April (256 grains/m³) and May (172 grains/m³), with the maximum daily average concentration reached on 8 May with 28 grains/m³ 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/m³ 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/m³ of air in Tulsa (United States), whereas for Bilbao (Spain) a total concentration of 6,118 grains/m³ 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/m³, of which 10,491 grains/m³ (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/m³, 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**