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Biogeography and bioclimatology in pollen forecasting

An example of grass in León (Spain) and Montréal (Canada)

ROSA MARÍA VALENCIA-BARRERA, PAUL COMTOIS and DELIA FERNÁNDEZ-GONZÁLEZ

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A comparative study of the atmospheric pollen content in two cities, located at similar latitudes, though in different continents, was undertaken. Special consideration was given to the meteorological determinants as shown by correlation analyses. In both localities, the contribution of Poaceae to the aerospora was quite distinct and varied from year to year. Analyses were carried out taking into account either years or cities separately or combined, and at two time scales: daily or weekly counts. Maximum temperature was the major meteorological determinant for daily grass pollen concentration values. Owing to its more arid climate, grass populations in León seem to react more to sunshine hours. Relative humidity and precipitation had a negative influence but at different time scales in the two localities. In León, they are related to everyday events such as convective storms, while in Montréal, the same events are related to low-pressure systems that have the same time scale as air masses. We found that wind speed was the only factor that acted differently in Montréal and León. In León, wind speed has the well-known dilution impact, while in Montréal, it has a positive impact by increasing pollen shedding from the anthers. Wind speed has therefore a stronger influence at two different stages of the aerobiological pathway in both localities.

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Ever since Bostock (1819) first described the clinical symptoms of hay fever which were recurrent at the time of the flowering of cereals, there have been a great many publications on the aerobiology of grasses. The Poaceae are now believed to be one of the most important causes of pollinosis in the world today.

With the advent of national networks of aerobiological stations and of continental airborne pollen databases, comparisons of results between pollen monitoring stations have become accessible. Hence, in many studies (e.g. Spieksma et al. 1989, Galán et al. 1995) this lead has been taken with some success. However, the main point of these intracontinental comparisons was the latitudinal variations of the parameters. Interestingly enough, nobody has ever sought to compare the latitudinal similarities between airborne grass pollen behaviour, as this can be visualized by regression parameters. Indeed, latitudinal variations are the single most important factors that pertain to the energy balance of the earth.

Pollination, a major biological phenomenon, is without doubt dependent on this input. For a family as integrated as the Poaceae (Acedo & Llamas 1999), qualitatively there should therefore be single pollination behaviour when the independent variables are established, even if quantitatively there can be different zonings (isopols). Biogeographical setting has been suggested as a major determinant for the airborne spora (Escamilla García 1997). The hypothesis that at the same latitudinal level the same behaviour would be

produced, as visualized by correlation coefficients, was tested in this study. In order to do so, we compared the seasonal differences of the grass pollen profiles and their meteorological determinants in two sites: Montréal (Canada) and León (Spain), located in two different continents, but at similar latitudes. Hence, the probability of the two locations having anything in common other than the latitude is quite remote.

Biogeographical and bioclimatic settings

Montréal is a large city located close to the Canada–USA border, at 45°28'N; 73°45'W and at 57 m a.s.l. (Fig. 1). Litynski (1984) defines the Montréal region from a climatic point of view as a zone with moderate temperatures (average annual temperature of 6.1°C), high humidity (total annual precipitations of 1036 mm) similar to a continental-type climate, because of its wide annual range of temperatures (record daily low and high temperatures of –37.2°C and 36.1°C, respectively). According to Rivas-Martínez (1997), Montréal has a temperate macro-bioclimate and is situated in the Atlantic region of North American. The natural vegetation which colonizes Montréal Island up to the banks of the St. Lawrence River is a deciduous forest comprising *Acer saccharum*, *A. rubrum*, *Fagus grandifolia*, and the more thermophilic *Carya cordiformis*, *C. ovata*, *Ostrya virginiana* and *Juglans cinerea*. A large proportion of these forests has been given over to agriculture, as the forests grow on the

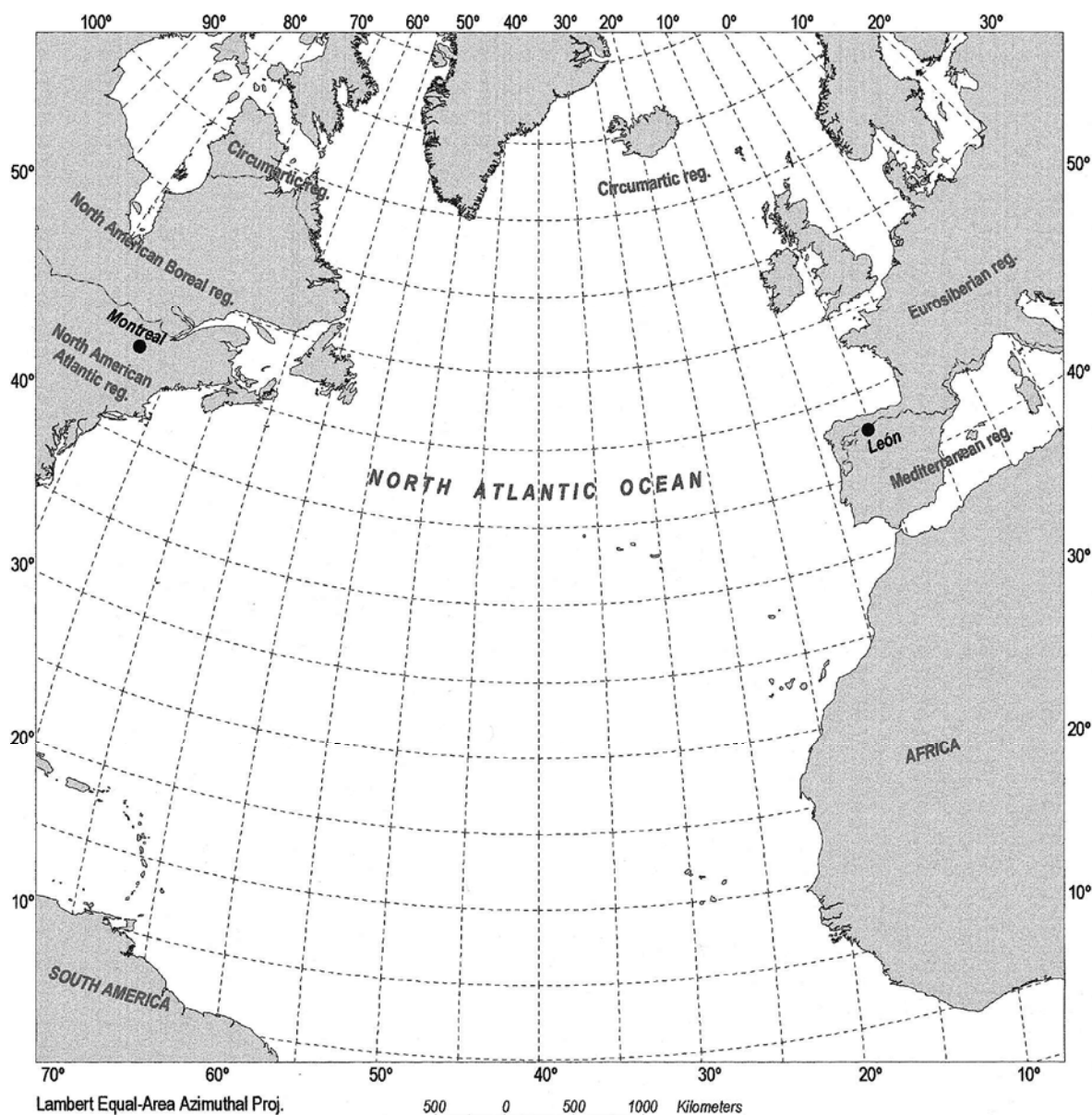


Fig. 1. Position of the localities studied.

most suitable land in the province. Willow (*Salix*) trees dominate on the riverbanks. Aerobiologically, Montréal grass accounts for only 3 to 5% of its annual airborne pollen, but up to 43% of hay-fever symptoms can be accounted for (Comtois & Gagnon 1988). It is, in fact, the second most important aeroallergen in the city. In open habitats, the most abundant grass species are: *Hordeum jubatum*, *Danthonia spicata*, *Festuca rubra*, *Poa pratensis*, *Agrostis stolonifera*, *Phragmites communis*, *Dactylis glomerata*, *Calamagrostis canadensis*, and *Phalaris arundinacea*.

León, a provincial capital in northwest Spain, is located at 42°34'N, 5°35'W (Fig. 1) and at 830 m a.s.l. and has a continental Mediterranean climate with an average annual temperature of 10.6°C and a total annual precipitation of 565 mm. It is thus warmer, though less humid, than Montréal.

The vegetation surrounding the city of León is composed of *Quercus pyrenaica* to the north and of *Quercus rotundifolia* to the east and west. *Lolium perenne*, *Holcus lanatus*, *Dactylis glomerata*, and *Poa pratensis* are the most commonly found taxa in the heavily exploited pastures. The different rivers that water the area are flanked by poplars, willows and elms. Aerobiologically, more or less 30% of the airborne pollen collected in León belongs to the grass family and is the main cause of pollinosis (Fernández-González et al. 1998).

MATERIALS AND METHODS

This study on the daily airborne pollen counts monitored in both cities was carried out in 1994 and 1995. A representative sample of the atmospheric pollen content was collected using a Hirst-type

volumetric sampler. The samplers were located at about 15 m above ground level, on the roof of the Veterinary Science Faculty in León, and on the roof of the Geography Department in Montréal, respectively. In both sites, daily slides were read following the method proposed by the Spanish Aerobiological Network (Domínguez et al. 1991). All concentrations used in this study are average daily pollen concentrations per m^3 of air.

The meteorological data used were those collected by the Centro Meteorológico Territorial de Castilla y León, a station at La Virgen del Camino, 6 km from the city of León; and by the Service de l'environnement, Environnement Canada, a station at Dorval Airport, 10 km from the city of Montréal. Variables used (daily average or total) were: maximum and minimum temperatures ($^{\circ}\text{C}$), relative humidity (%), precipitation (mm), wind speed (m/s) and sunshine (hours).

In order to obtain realistic statistical analyses, our sampling was limited to a period when null values of grass pollen were at their minimum. The beginning and end of the study period for each year were set proportionally to the yearly total. The discarded extremes of the yearly grass pollen profiles corresponded to 10% of the total annual pollen concentration; 5% at each end of the season. Since the frequency distribution of all pollen counts is not normally distributed, a non-parametric correlation (Spearman ρ) was used throughout this study.

RESULTS

In both localities, the contribution of Poaceae to the aeropora was quite distinct and changed from year to year (Fig. 2 A, B). In León, the main grass pollen season extended from week 20 to 28 in 1994 and from week 10 to 30 in 1995. Maximum values were always found in June, more specifically in week 23, with a weekly sum of 971 pollen grains/ m^3 in 1994 and of 586 pollen grains/ m^3 in 1995 (Fig. 2 A). Between October and January, Poaceae pollen is scarce.

In Montréal, pollen is only present in the atmosphere from April to October, which is due to a 6-month snow cover. For both study years, grass pollen was found between weeks 22 and 38. June was also the month with the highest recorded values with 208 pollen grains/ m^3 in week 27 in 1994, and 181 pollen grains/ m^3 in week 23 in 1995 (Fig. 2 B).

In León, the results of a correlation analysis for the whole period studied, between the meteorological parameters on the one hand and the daily pollen concentrations on the other, reveal a positive and significant correlation with maximum and minimum temperatures and sunshine hours, and a negative (but still significant) correlation with relative humidity, wind speed and precipitation (Table I). Thus all the selected variables were significant. If both years are considered separately, only maximum temperature and sunshine hours remain positively significant, but their order of importance is reversed; while only relative humidity remains negatively significant in 1994. Meanwhile, in 1995, the situation is different, with maximum, minimum temperatures and sunshine hours again having a positive and significant influence and relative humidity and wind speed showing a negative and significant correlation. If the time scale of the analysis is changed, from a daily period to a weekly integration, the level of correlation becomes higher (average significant ρ of 0.66 instead of 0.38) but if all positive factors are significant, only relative humidity shows a negative significant correlation. Moreover, sunshine hours now surpass the maximum temperature influence (ρ of 0.72), while the nega-

tive influence of relative humidity equals it (both ρ of 0.69, with a different sign). The weekly picture presented in the different years is similar.

In contrast, the correlation analysis for the Montréal data shows correlation levels of about half those in León (average ρ of 0.19 when both years are considered). Relative humidity, precipitation and sunshine hours are no longer significant. The largest decrease in influence, compared with the León situation, is for sunshine hours, and the influence of wind speed changes from a negative, dilutive effect to a positive, turbulent effect. If both years are considered separately, only temperatures (both maximum and minimum) are of importance in Montréal in 1994, while in 1995 only the influence of wind speed could be detected. If weekly values are considered instead of daily values, again, as for León, correlation coefficients are much higher (average significance ρ of 0.59), and, here again, relative humidity has no marked influence, but wind speed regains its dilutive effect. The main difference between years at this level is that in 1994 the influence of wind speed was at its highest level.

In order to establish a standard for comparisons, all our combined data sets (León and Montréal, 1994 and 1995) were considered in one single analysis (Table II). If our hypothesis is validated, this should permit the behaviour of Poaceae pollen to be put in the forefront. Here daily values are mostly governed by the positive influence of sunshine hours and maximum temperatures, and almost equally, by the negative influence of relative humidity. Precipitation is somewhat less influential as an explanatory factor. At the weekly time scale, we again find the above-mentioned increase in significance as the time scale is upgraded (average ρ of 0.48 instead of 0.28). However, if the positive influence of temperatures (to which is added the contribution of minimum temperature) and sunshine hours were to double (in fact, an increase of an average factor of 2.1), negative determinants would maintain the same importance. Moreover, precipitation would disappear as a determinant at this scale, while wind speed would reappear.

DISCUSSION

We found that maximum temperature was the major meteorological determinant for daily grass pollen concentration values. In both continents, the minimum temperature was the same, but had a somewhat lower (on average by 32%) effect. This is not unexpected since these two variables are highly intercorrelated. Maximum temperature has a greater influence, probably because at the time of grass pollination, in contrast to early (spring) flowering trees for example, minimum temperature does not represent a threshold value in June for herbaceous plants, while maximum temperature definitively has a quantitative influence on growth and physiology. The sunshine hours variable is also an "integrated" variable of air temperature, to which the cloud cover is added. It seems that because of its more arid climate, the grass population in León reacts to this variable, while in Montréal its daily significance is lost.

Many authors have shown that warm and dry periods at the time of anther formation are conducive to increase in pollen in the atmosphere (Moselholm et al. 1987, Spieksma

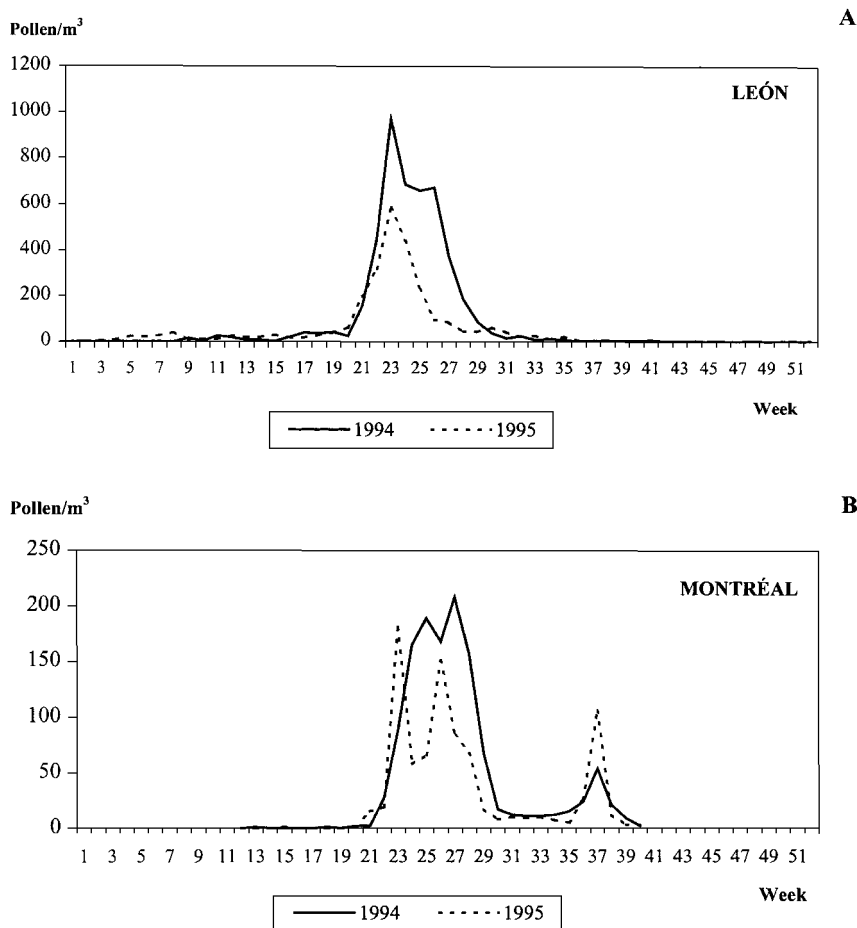


Fig. 2. Weekly concentration of Poaceae pollen in 1994 and 1995: (A) León and (B) Montréal.

et al. 1989, Cadman 1991, Galán et al. 1995). Most of these studies have shown that temperature, whether minimum, maximum or mean values, had the best correlation with daily pollen counts. Norris-Hill (1997) established an optimal temperature range of 21.1 to 25°C for London. This is the same amplitude that was found in our study for the maximum concentration of grass pollen in the air. Most of the above-mentioned studies are located in the temperate-oceanic sub-Mediterranean climates (London, Leiden and Helmond), where the main grass pollen season is in June and July.

Even though the pollen concentrations (for Poaceae) in the atmosphere of both localities are different (by an annual factor of between 3.0 and 4.5), the grass pollen season presents similar behaviour that can only be explained at the biogeographical and bioclimatic global levels. Indeed, both locations are found latitudinally in temperate zones, León in the true temperate (35°–45°), Montréal in the high temperate (45°–52°) zones (Rivas-Martínez 1997). A parallel can be drawn between the Atlantic biogeographical region in North America and the Eurosiberian region of Europa. Even though León is situated in the Mediterranean region, it is located at a mere 30 km south of the Eurosiberian border region; a distance probably insignificant as far as grass pollen dispersal is concerned. Likewise, Montréal is located at the northern limit of its own biogeographical region (the Hemlock-White

Pine-Northern Hardwoods), and may to some extent be representative of more southerly located areas.

This allows annual climatological changes and consequently vegetation behaviour to be quite similar in Montréal and León, especially in the summer months (Fig. 3) and therefore some resemblance can be seen between the grass phenologies in both localities. We have already mentioned that maximum temperature was found to be the major determinant of Poaceae atmospheric pollen content. If we look at the bioclimatic setting of both localities, we find an annual summation of positive temperatures of 1022 and of 1269 and a summer summation of 594 and 547 in Montréal and León, respectively.

In both localities, evapotranspiration is at its maximum between May and September, with June and August having similar values. The aridity index of both cities is very similar (Table III), and is governed by a frost period in Montréal and a summer dry period in León. Therefore both the water reserves and efficient temperatures are of the same level in both localities at the time of the main grass pollen season (MPS). By decreasing the floatability of pollen grains, relative humidity increases the effect of the terminal velocity (V_s), and by its washout activity in the atmosphere, precipitation decreases the pollen content. These phenomena can be seen in León, but cannot be actively seen in Montréal, probably

Table I. *Spearman's correlation coefficient among daily and weekly average pollen concentrations and meteorological parameters. Significance level: * $p < 0.05$.*

	León					
	Daily 1994	1995	1994–1995	Weekly 1994	1995	1994–1995
Temperature max.	0.36*	0.61*	0.60*	0.65*	0.75*	0.69*
Temperature min.	0.03	0.45*	0.38*	0.45*	0.64*	0.54*
Relative humidity	–0.45*	–0.42*	–0.33*	–0.70*	–0.67*	–0.69*
Wind speed	–0.21	–0.31*	–0.23*	0.19	–0.06	–0.21
Precipitation	–0.31	–0.09	–0.18*	–0.32	–0.20	0.10
Sunshine	0.53*	0.37*	0.54*	0.69*	0.71*	0.72*

	Montréal					
	Daily 1994	1995	1994–1995	Weekly 1994	1995	1994–1995
Temperature max.	0.43*	0.14	0.23*	0.84*	0.73*	0.79*
Temperature min.	0.31*	0.05	0.17*	0.86*	0.68*	0.79*
Relative humidity	–0.13	–0.20	–0.14	0.21	0.20	0.19
Wind speed	0.11	0.28*	0.16*	–0.62*	–0.19	–0.39*
Precipitation	0.01	–0.05	–0.03	0.00	–0.05	–0.02
Sunshine	0.15	0.03	0.06	0.38*	0.42*	0.40*

Table II. *Spearman's correlation coefficient among daily and weekly average pollen concentrations and meteorological parameters, combined data set (León and Montréal, 1994 and 1995).*

Significance level: * $p < 0.05$.

	Daily	Weekly
Temperature max.	0.29*	0.71*
Temperature min.	0.04	0.61*
Relative humidity	–0.39*	–0.25*
Wind speed	–0.05	–0.22*
Precipitation	–0.14*	0.05
Sunshine	0.32*	0.63*

Table III. *Historical registers of the bioclimatic data for 36 years in León and 68 years in Montréal.*

	León	Montréal
Temperature mean (°C)	10.6	6.1
Temperature max. (°C)	15.8	10.2
Temperature min. (°C)	5.2	1.7
Precipitation (mm)	565.0	1036.0
Evapotranspiration	652.0	599.0
Annual positive temperature (°C)	1269.0	1022.0
Summer temperature (°C)	547.0	594.0
Annual aridity index	1.2	0.6

because in Montréal their global effect on pollination is lowered by the fact that water is not a limiting factor at this time of the year (Fig. 3). Similar results were found for a comparative latitudinal/longitudinal study of ragweed pollination determinants (Comtois & Gagnon 1988).

Wind speed was the only factor that acted differently between Montréal and León. In León, it has a well-known

dilution impact, by increasing the volume of air in which the pollen cloud is travelling. In Montréal, it has a positive impact, by increasing pollen shedding from the anthers. Wind speed is a very difficult parameter to measure, since its effect can be dramatic even in a short period of time. It seems that, on average, it has a stronger influence at two different stages of the aerobiological pathway in both localities: at the emission phase in Montréal (Comtois 1997), and at the dispersal phase in León (Comtois et al. 2000).

When a larger time scale is considered, correlation coefficients increase as variability decreases. However, in addition, there is again a biogeographical effect: negative factors, with the exception of relative humidity, disappear in León but reappear in Montréal. Here, even wind speed regains its negative impact. Positive determinants related to temperature, either directly (maximum or minimum values) or indirectly (via insolation and thermal convection), are probably governed more by air mass movements that remain constant for periods of a few days up to a week. In León in summer, negative determinants such as relative humidity and precipitation are related to daily events such as convective storms. In Montréal, the same events are related to low pressure systems that have the same time scaling as air masses. Wind speed fluctuations also seem to be a convective element in León, whereas wind speed is more stable in Montréal and therefore appears only at the weekly level of analysis.

CONCLUSIONS

In addition to confirming previous studies on grass anemophilous pollination behaviour, two important aspects have been put forward in this comparative study. First, pollination determinants or their parameters, often called forecasting models, vary between studies, while the pollination behaviour

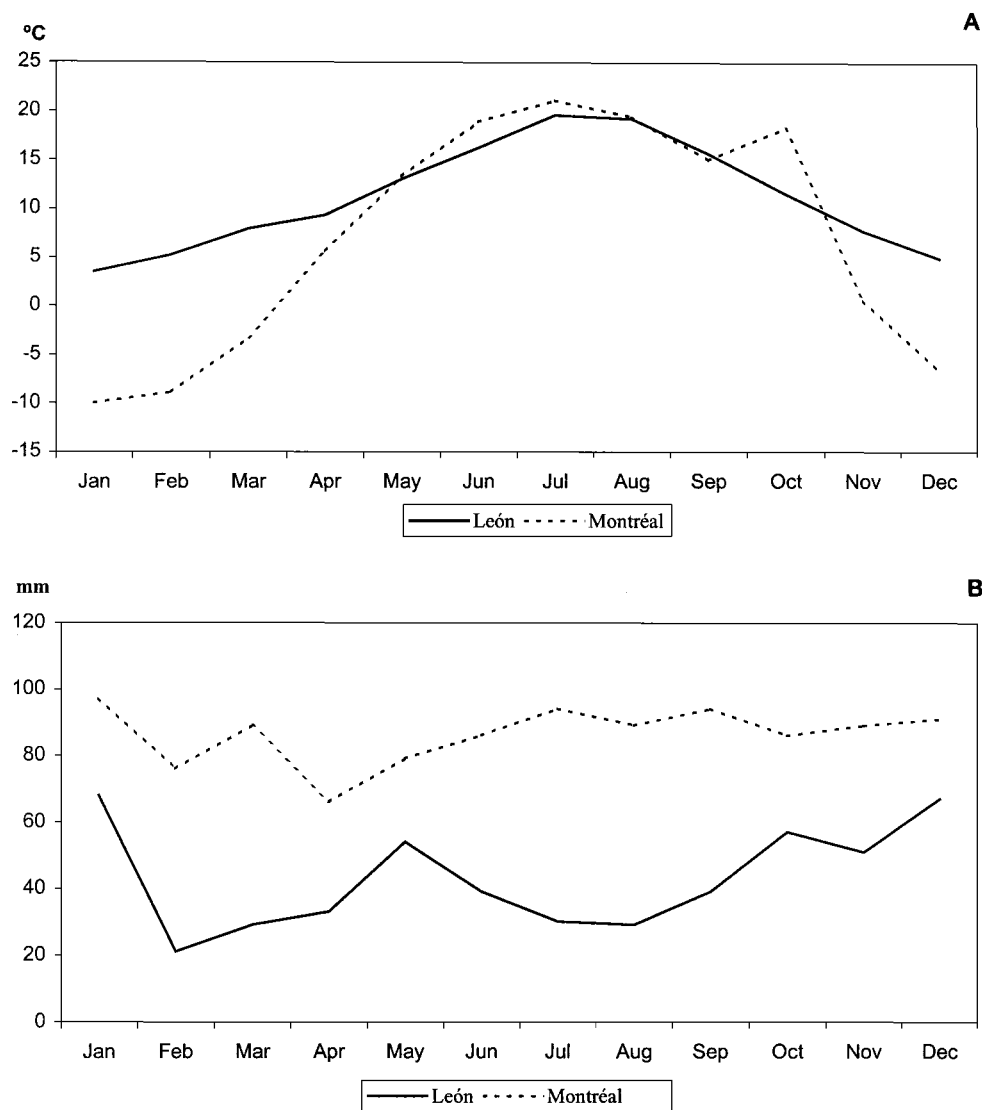


Fig. 3. Historical registers: (A) mean temperature and (B) mean precipitation, for 36 years in León and 68 years in Montréal.

probably remains the same. The key element to consider here is the bioclimatic setting of the study. If plants do not change their behaviour, a change in the availability of resources will definitively change their needs. There is a tendency to compare sites which come from national or continental networks without first considering their biogeographical segregation. We believe that if a similarity in bioclimatic regimes were considered, more similarities would then be found between models from different studies. Secondly, the selection of climatic determinants must be carried out by correlating the time scale of the pollen content considered with that of the atmospheric phenomena, which would bring the considered changes in weather variables.

REFERENCES

- Acedo, C. & Llamas, F. 1999. The genus *Bromus* L. (Poaceae) in the Iberian Peninsula. – *Phanerogamarum Monographiae* XXII. J. Cramer, Stuttgart.
- Bostock, J. 1819. Case of a periodical affection of the eyes and chest. – *Med. Chir. Trans.* 10: 161.
- Cadman, A. 1991. Airspora of Johannesburg and Pretoria, South Africa. Meteorological relationships. – *Grana* 30: 181–183.
- Comtois, P. 1997. Pollen dispersal and long distance transport: the case of thermophilic pollen in subarctic Canada. – *Aerobiologia* 13: 37–42.
- Comtois, P. & Gagnon, L. 1988. Concentration pollinique et fréquence des symptômes de pollinose. Une méthode pour détecter les seuils cliniques. – *Rev. Fr. Allergol.* 28: 279–286.
- Comtois, P., Fernández-González, D., Valencia-Barrera, R. M., Sanchez, J. L., Fraile, R. & Rodier, S. 2000. Pollen content study of the lower atmosphere in León (Spain) by use of a tethered balloon. – *Aerobiologia* 16: 187–191.
- Dominguez, E., Galán, C., Villamandos, F. & Infante F. 1991. Handling and evaluation of data from the aerobiological sampler. – *Monografias REA/EAN* 1: 1–18.
- Escamilla García, B. 1997. Étiologie comparative des maladies respiratoires d'une population d'enfants à Montréal et Vancouver: Regard sur les moisissures de l'air intérieur. – Ph.D. Thesis, Université de Montréal.

- Fernández-González, D., Valencia-Barrera, R. M., Vega, A. & Gonzalo-Requés, F. 1998. Aerobiología en Castilla y León: Estación de León (1997). – Rea 4: 61–64.
- Galán, C., Emberlin, J., Domínguez, E., Bryant, R. H. & Villamandos, F. 1995. A comparative analysis of daily variations in the Gramineae pollen counts in Cordoba, Spain and London, UK. – Grana 34: 189–198.
- Litynski, J. K. 1984. The numerical classification of the world's climate. – Serv. Environ. Atmosph., Environnement Canada, ONT. Downsview.
- Moselholm, L., Weeke, E. R. & Petersen, B. N. 1987. Forecast of pollen concentrations of Poaceae (grasses) in the air by time series analysis. – Pollen & Spores 2(3): 305–322.
- Norris-Hill, J. 1997. The influence of ambient temperature on the abundance of Poaceae. – Aerobiologia 13: 91–97.
- Rivas-Martínez, S. 1997. Syntaxonomical synopsis of North America natural potential vegetation communities. – Itinera Geobot. 10: 5–148.
- Spieksma, F. TH. M., Frenguelli, G., Nikkels, A. H., Mincigrucci, G., Smithuis, L. O. M. J., Bricchi, E., Dankaa, W. & Romano, B. 1989. Comparative study of airborne pollen concentrations in central Italy and the Netherlands (1982–1985). Emphasis on *Alnus*, Poaceae and *Artemisia*. – Grana 28: 25–36.