

# Analysis of environmental factors and their effects on fungal spores in the atmosphere of a tropical urban area (San Juan, Puerto Rico)

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Received: 15 August 2008 / Accepted: 10 December 2009  
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**Abstract** In Puerto Rico, respiratory diseases affect a significant percentage of the population, and it is possible that the environmental factors unique to the island, such as easterly winds, dense vegetation, and high humidity, may increase the concentration of airborne biological particulates that could distress susceptible individuals. As most studies characterized fungal spores and pollen in temperate zones, we wanted to describe their concentrations in a tropical zone. The Allergenco<sup>®</sup> (MK3) spore trap was used to monitor airborne spores and pollen concentrations for 12 months starting on May 2005. During the length of the study, silicone grease-coated microscope slides captured 12 impacts daily, which were then stained with calcofluor and observed under the microscope with bright field and ultraviolet light. Atmospheric conditions were recorded with the Precision Weather Station<sup>®</sup>. Precipitation, dew point, and relative

humidity promote the presence of fungal spores in San Juan throughout the year, with basidiospores being the most frequent. Spore concentrations were higher during the early morning hours all the year around. Wind and gusts were dispersal factors, and humidity and the dew point favored the release of spores into the atmosphere. In contrast to spores, pollens were not found to be affected by any of the meteorological factors and no distinctive patterns were found. Describing how airborne spores and pollens, many of which have allergenic potential, behave in the tropics, such as in San Juan, Puerto Rico, could be used to design preventive measures for the benefit of the sensitized population. Information about the presence and abundance of aeroallergens will assist in the diagnosis of allergic rhinitis and asthma on the island.

**Keywords** Fungal aerosols · Spore calendar · Tropical Aerobiology · Environmental factors

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## 1 Introduction

In Puerto Rico, respiratory conditions constitute an important public health problem, affecting 33.3% of the children attending school, of which only 51.3% receive treatment (Perez Perdomo et al. 2003). The east-central region of the island has been identified by the Puerto Rico Department of Health as one with the highest prevalence of respiratory diseases, affecting

mostly the population between 0 and 17 years of age (Seguinot-Medina and Rivera-Rentas 2006). Loyo-Berrios et al. (2006) found a high prevalence of asthma in the northeastern area of Puerto Rico (Rio Grande and Loiza municipalities), where 46% of the children in elementary school and 24% of the young adults in secondary school were affected. According to Cohen et al. (2007), the incidence of Puerto Rican children living in Puerto Rico (41.3%) was higher than the prevalence among Puerto Rican children living in the Bronx (35.3%). If a high proportion of Puerto Rican individuals are genetically predisposed to asthma, then unique environmental and tropical characteristics of Puerto Rico could have an additive effect that could result in a much higher incidence (Loyo-Berrios et al. 2006).

Puerto Rico is the most westerly of the Greater Antilles islands in the Caribbean Sea. It is characterized by a tropical climate with moderate temperature and high precipitation throughout the year (López Marrero and Villanueva Colon 2006). Its unique topographical and geological characteristics favor the existence of great diversity of forests and ecosystems (López Marrero and Villanueva Colón 2006). The city of San Juan, located in the northeastern region of Puerto Rico, is characterized by tropical climate, urban land cover and use, moist soils, and dense vegetation. These factors, together with the easterly trade winds from the Atlantic Ocean, induce a microclimate that could influence the concentration of airborne particulates (e.g., organic particles, viruses, bacteria, fungi, pollen, etc.; Velázquez-Lozada et al. 2006). Although previous studies indicate that fungal spores are the most common biological particulate in the atmosphere of temperate regions, limited information is known about their prevalence in tropical regions (D'Amato and Spieksma 1995; Horner et al. 1995; Burge and Rogers 2000).

The presence of spores in the air is related to multiple aerodynamic factors, such as spore size, shape, weight, and hygroscopic and electrostatic properties of their walls (D'Amato and Spieksma 1995; Newhouse and Levetin. 2004; Okten et al. 2005). Nevertheless, weather variables (wind, humidity, temperature, etc.) also influence spore behavior and dispersion in the atmosphere (Burch and Levetin 2002; Burge 2002; Levetin and Horner 2002; Bartra Tomas 2003; Ivey et al. 2003; Rodriguez-Rajo et al. 2004).

Aerobiological studies in temperate regions have found that the most common spores in urban atmospheres belong to basidiomycetes, ascomycetes, and those of the genera *Penicillium/Aspergillus*, *Cladosporium*, *Alternaria* and other asexual fungi, many of which have been associated with allergic respiratory diseases (Chew et al. 2000; Levetin and Van de Water 2001; Levetin and Horner 2002; Newson et al. 2000; Bartra Tomas 2003). However, the spore distribution is not equal around the planet, and fungi common in temperate regions are not necessarily predominant in the tropics.

From previous studies, pollen diversity in the air has been associated with variations in meteorological variables, changes plant distribution, and land use (Busse et al. 2000; Burge 2002). In addition, the type of vegetation present at a particular location is also important. For example, the proportion of wind-pollinated plants differs with latitude and altitude, being most prevalent in temperate areas and lowest in forested tropical zones (Busse et al. 2000). However, few studies have characterized the diversity of airborne pollen in tropical regions and the effects of meteorological factors have on their concentrations.

The present study aims to characterize the predominant airborne fungal spores and pollen and to determine how environmental variables influence their concentration and dispersal in the tropical atmosphere of a tropical urban area San Juan, Puerto Rico.

## 2 Materials and methods

The air sampler (Allergenco® MK3) is an efficient, time lapse, 'grab-type' volumetric slit impaction sampler that collects multiple discrete 10-min samples directly at a flow of 15 L per min onto a silicon-greased laboratory slide. The collection characteristics of the MK3 have been shown to be comparable to the Hirst-type volumetric spore trap (Portnoy et al. 2000). The time interval formula from the Allergenco MK3 owner's manual and user's guide was used to convert raw counts to particle/m<sup>3</sup>. Particle density = raw counts/volume sampled. Volume sample = (fraction of trace) × (flow rate) × (exposure time). The MK3 and the equipment measuring weather factors (Precision Weather Station®) were located on the roof of the main building (30 m above

ground level) of the Medical Sciences Campus of the University of Puerto Rico, in San Juan.

To collect spores and pollen, each day (May 2005–May 2006) a microscope slide covered with silicone grease was placed in the MK3 every morning and changed every 24 h. The intradiurnal concentrations were calculated by counting the total spores and pollens on the 12 traces (one impact taken every 2 h during a 24-h period) that were stained with calcofluor Fungi Fluor™ kit (Polysciences, Inc. (Fisher and Cook 1998). The stained slide was analyzed with the NIKON ECLIPSE 80 fluorescence microscope using 60× (C-FL UV-2 E/C DAPI TE 2000 fluorescence filter cube) to quantify total fungal spores and pollens and identify them into their corresponding group or genera (Grant Smith 2000). The criteria for the abundance of the aeroallergens were based on their daily concentrations according to the National Allergy Bureau scale, American Academy of Allergy, Asthma and Immunology (AAAAI. NAB: reading charts 2009).

Weather conditions were monitored daily for the following factors: rain, wind direction and speed, wind gusts, dew point, temperature, and the percentage of relative humidity. Because meteorological variables fluctuated constantly during the period of the study, we selected the days in which these factors were recurrent, such as days of high humidity, or gusts, to analyze the differences in spore concentrations against these factors. To test our hypothesis about the impact of meteorological factors on the spore concentrations, regression and correlation analysis were performed. Parametric statistical tests were used to analyze the results. The daily average spores/m<sup>3</sup> was log-transformed to adjust for a normal distribution. Because with various variables the transformed variable turned into zero, we choose the formula  $\ln(x^2 + 1)$ . This analysis confirmed their normal distribution. Pearson correlation tests were used to determine whether there is a statistically significant relationship between the spore concentrations and the meteorological parameters. Regression analysis was performed to explain the change of the dependent variable (spore concentrations) in relation to the independent variable (meteorological factors). Therefore, descriptive statistics were used to design annual calendars, calculate the monthly averages, and to determine the changes in spore concentrations throughout the day. Student's *t*-test was used to

find correlations between total spores during the rainy and dry seasons, spores average during the day and night hours, and to determine whether a specific meteorological factor recorded at specific days, was statistically significant for the observed spore concentrations during the same period. For the data related to pollen, the concentrations indicate that they were non-normally distributed; Spearman test was used to determine the relative abundance of pollen and the meteorological factors (Morales et al. 2004).

### 3 Results

As seen in Fig. 1, fungal spores were present in the San Juan atmosphere throughout the year, with daily means ranging from 288 to 51,112 spores/m<sup>3</sup>. Three peaks of very high concentrations (>50,000 spores/m<sup>3</sup>) were detected on April, June, and September, in which the predominant spores were basidiospores. According to the scale of the National Allergy Bureau of the American Academy of Allergy, Asthma and Immunology, low (below 6,500 spores/m<sup>3</sup>) to moderate (6,500–12,999 spores/m<sup>3</sup>) concentrations of fungal spores were detected during the dry months (January through March), while high (13,000–49,999 spores/m<sup>3</sup>) concentrations were recorded during on the rainy season (April, May, and September through November).

The genera most frequently detected during the study were *Penicillium* sp./*Aspergillus* sp., *Cladosporium* sp., and *Ganoderma* sp, present at low concentrations (Fig. 2), while basidiospores and ascospores were detected at moderate concentrations (Fig. 3). Basidiospores and ascospores were the most common airborne spores detected in San Juan throughout the year; nevertheless, they predominated during the rainy months and decrease during the dry season. These differences were statistically significant (*P* value = 0.001 for all of the fungal groups included in the study, Table 1). The calcofluor stain increased the detection of colorless basidiospores and ascospores, which stained bright blue by fluorescence microscopy; nevertheless, not all fungal spores were stained. Other fungi, such as *Fusarium*, *Dreschlera*, and *Alternaria* were occasionally observed during the study.

To determine the relationship between meteorological factors (temperature, dew point, relative

**Fig. 1** Mean total atmospheric fungal spores concentrations per day per every month in 2005–2006. The bar indicates 95% confidence interval around the mean

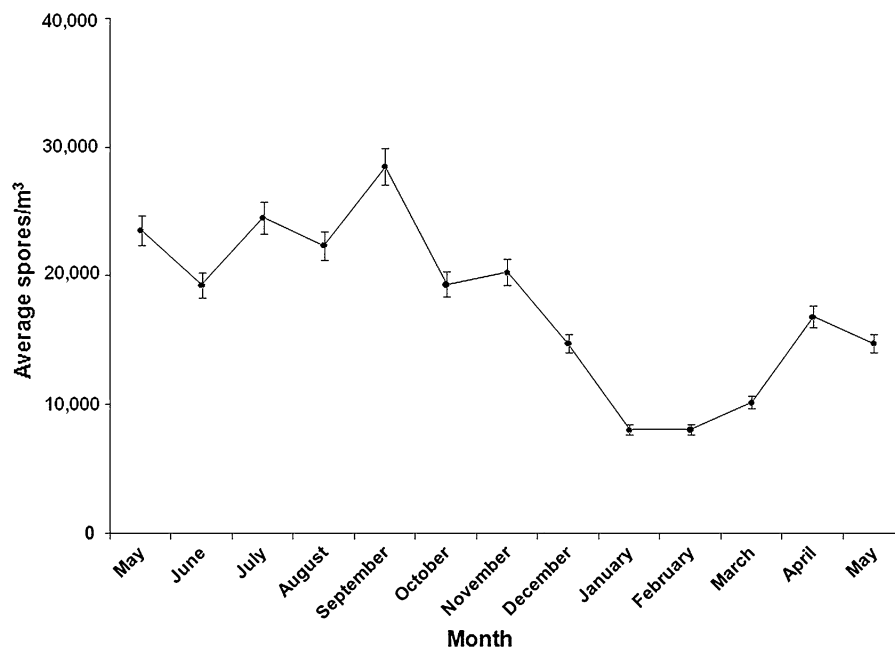
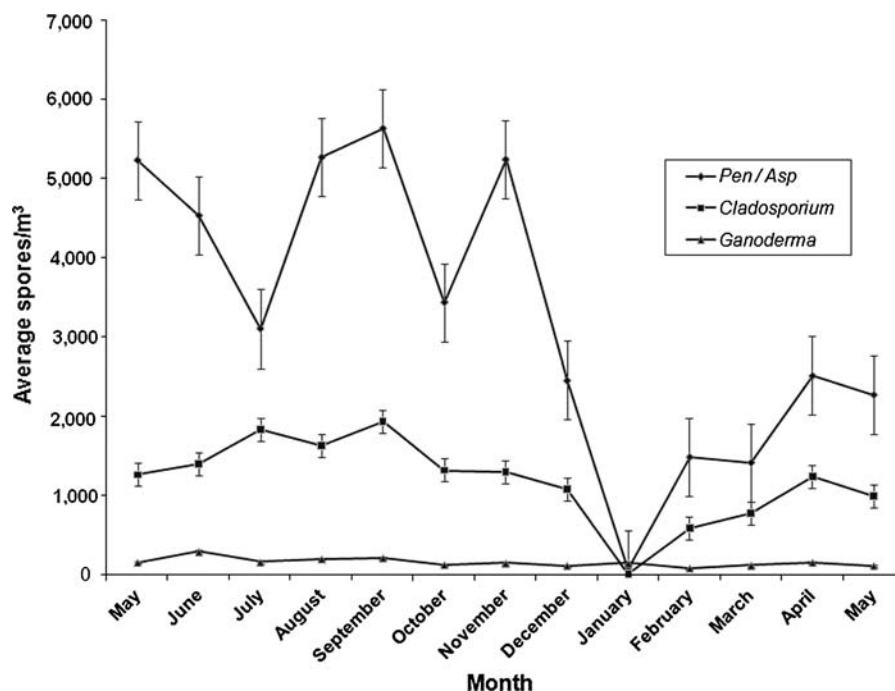


**Fig. 2** Mean total atmospheric *Ganoderma* sp., *Cladosporium* sp. and *Penicillium* sp./*Aspergillus* sp. type spores concentrations per day per every month in 2005–2006. The bar indicates 95% confidence interval around the mean



humidity % RH, wind, wind gusts, and precipitation) and each spore type studied, the Pearson correlation analysis was performed. As seen in Table 2, there were positive correlations between airborne fungal spore concentrations (total and for each group) and temperature, dew point, and relative humidity. A

negative correlation of the airborne spore concentrations was observed with wind speed and gusts, while no correlation was observed with precipitation.

As we were aware of the significant relationships among the variables studied, we performed a regression analysis between the variables total spore

**Fig. 3** Mean total atmospheric basidiospores and ascospores concentrations per day per every month in 2005–2006. The bar indicates 95% confidence interval around the mean

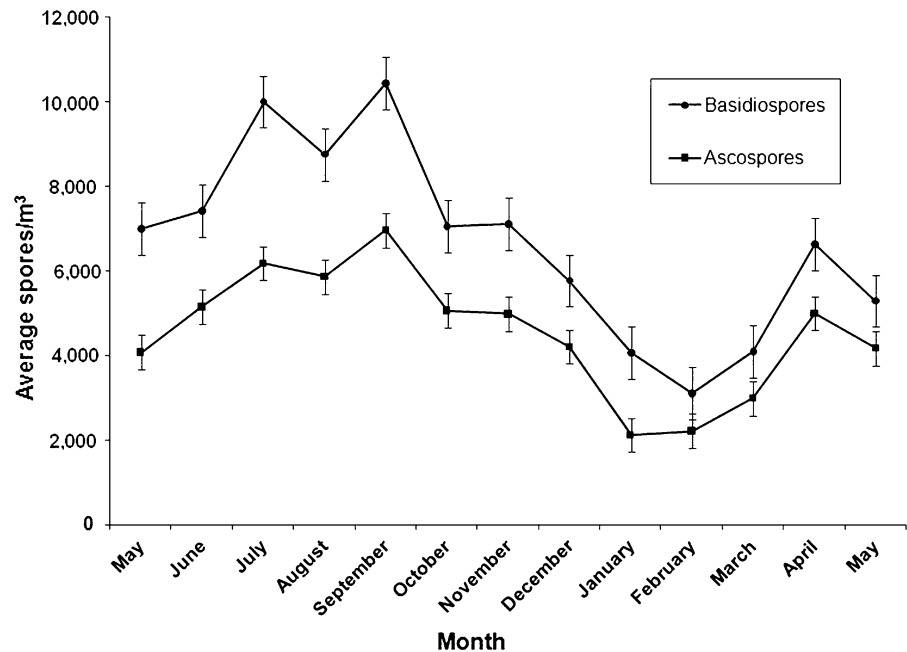


**Table 1** Comparison of mean spore concentrations of known fungal allergens during the rainy versus dry seasons in San Juan, Puerto Rico

| Season    | Statistics      | <i>Ganoderma</i> | <i>Cladosporium</i> | Pen/Asp | Ascospores | Basidiospores |
|-----------|-----------------|------------------|---------------------|---------|------------|---------------|
| Dry       | Mean            | 90               | 655                 | 1,406   | 2,560      | 3,433         |
| (Jan–Mar) | SD              | 95               | 462                 | 1,312   | 1,735      | 2,442         |
| Rainy     | Mean            | 165              | 1,574               | 4,856   | 5,838      | 8,497         |
| (Sep–Nov) | SD              | 111              | 722                 | 3,113   | 2,546      | 3,911         |
|           | <i>t</i> value  | −4.38            | −9.3                | −8.93   | −9.42      | −9.44         |
|           | <i>P</i> value* | 0.001            | 0.001               | 0.001   | 0.001      | 0.001         |

\* *P* value < 0.05 differences are significant

concentrations and each of the meteorological factors to determine their relationship. The results in table 3 indicate that the main variables affecting the concentration of fungal spores are the dew point and gust speed ( $r^2 = 65.6$ ).

Next, we examined the effect of the rain on the concentration of the fungal particulate. As seen in Fig. 4, high-intensity rain had precipitating effect on fungal spores in the atmosphere by diminishing their concentration; nevertheless, in the subsequent hours, in which humidity accumulated in the environment, the concentration of fungal aerosols also increased, with significant differences in the concentrations of spores during and after the rain events ( $P$  value = 0.001).

Our results demonstrate that wind speed and gusts (Fig. 5) served as dispersal factors of fungal spores (proportionally inverse relationship) as the concentration of spores was significantly lower in the presence of high winds and gusts ( $P$  value = 0.001). However, dew point (Fig. 6) promotes the release of spores representing a directly proportional relationship ( $P$  value = 0.001). Although temperature in tropical regions does not vary significantly, high concentrations of fungal spores were observed during the lowest temperatures (data not shown).

Throughout the year, higher concentrations of fungal spores were consistently observed at midnight and early morning hours when compared to concentrations observed at noon ( $P$  value = 0.001). This

**Table 2** Correlation analysis of spore concentrations versus meteorological factors: temperature, dew point, humidity, wind, gust speed, and precipitation

| Meteorological factor | Total spores     | <i>Ganoderma</i> | <i>Cladosporium</i> | <i>Pen Asp</i>  | Ascospores      | Basidiospores   |
|-----------------------|------------------|------------------|---------------------|-----------------|-----------------|-----------------|
| Temperature           | 0.477<br>0.000*  | 0.310<br>0.000   | 0.466<br>0.000      | 0.393<br>0.000  | 0.533<br>0.000  | 0.636<br>0.000  |
| Dew point             | 0.662<br>0.000*  | 0.413<br>0.000   | 0.635<br>0.000      | 0.570<br>0.000  | 0.711<br>0.000  | 0.652<br>0.000  |
| Humidity              | 0.413<br>0.000*  | 0.201<br>0.011   | 0.427<br>0.000      | 0.218<br>0.003  | 0.329<br>0.000  | 0.421<br>0.000  |
| Wind                  | −0.278<br>0.000* | −0.322<br>0.000  | −0.523<br>0.000     | −0.312<br>0.000 | −0.257<br>0.000 | −0.383<br>0.000 |
| Gust speed            | −0.520<br>0.000* | −0.336<br>0.000  | −0.413<br>0.000     | −0.395<br>0.000 | −0.369<br>0.000 | −0.434<br>0.000 |
| Precipitation         | 0.059<br>0.515   | 0.093<br>0.724   | 0.081<br>0.605      | 0.026<br>0.548  | 0.046<br>0.393  | 0.062<br>0.367  |

\*  $P$  value < 0.05 differences are significant

**Table 3** Regression analysis of total spore concentration versus meteorological factor: temperature, dew point, humidity, wind, gust speed, and precipitation

| Statistics                                                                                                                                                           | Constant | Min. temperature | Dew point              | Humidity                     | Wind  | Gust speed | Precipitation |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------------|------------------------|------------------------------|-------|------------|---------------|
| The regression equation is: Spores total = 6114 − 0.083 min. temperature + 0.282 dew point − 0.0085 humidity + 0.0074 wind − 0.883 gust speed − 0.0056 precipitation |          |                  |                        |                              |       |            |               |
| $t$ value                                                                                                                                                            | 7.620    | −1.380           | 6.050                  | −0.850                       | 0.180 | −1.650     | −1.010        |
| $P$ value*                                                                                                                                                           | 0.000    | 0.096            | 0.000                  | 0.246                        | 0.622 | 0.004      | 0.231         |
|                                                                                                                                                                      |          | $S = 0.713,877$  | $R\text{-sq} = 65.6\%$ | $R\text{-sq (adj)} = 63.5\%$ |       |            |               |

\*  $P$  value < 0.05 differences are significant

intradiurnal rhythm, in which the highest abundance of spores present between the midnight and early morning period, suggests an active release mechanism induced by the high dew point and increased humidity prevalent at dawn (Fig. 7).

In Puerto Rico, where there is no seasonal fluctuation, various trees bloom all year long; nevertheless, we found pollen counts to be much lower than the fungal spores (Fig. 8). The yearly pollen index of trees, grass, and weeds were 6,288, 3,136, and 606, respectively. Among trees, the most frequently detected genus was *Cecropia* sp. followed by lower levels of others such as *Artocarpus* sp., *Casuarina* sp., and *Rhizophora* sp., while *Gramineae* were the most common for herbs. *Rumex* sp. was the most common weed pollen. The pollen concentrations were correlated with the meteorological variables using non-parametric models (Spearman test). These variables did not significantly affect the

concentration of pollen in the atmosphere (data not shown).

#### 4 Discussion

Contrary to temperate zones where numerous studies have been done and where spore and pollen calendars exists, the concentration of spores and pollen in the atmosphere of the tropics have not been totally described (Tan et al. 1992). It has been found that the dynamics of spores and pollen changes according to multiple factors, such as geographic position of the country in which the study was performed, atmospheric contamination, the climate, and numerous other intrinsic factors (Levetin and Horner 2002). In temperate regions, the summer and fall are the seasons with the highest concentration of spores in the atmosphere due to the presence of high amounts

**Fig. 4** Relationship between precipitation and total atmospheric spore concentrations

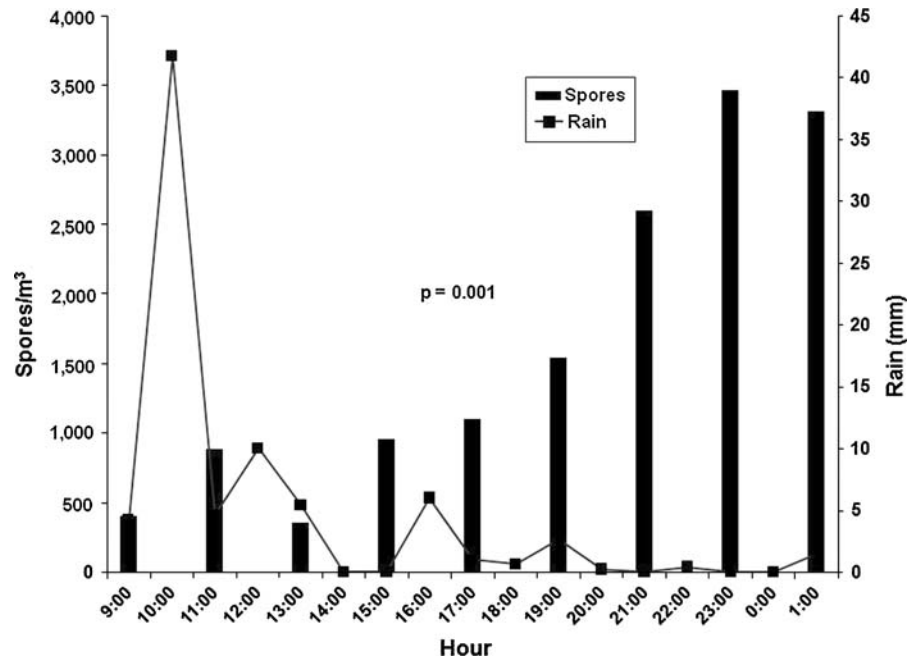
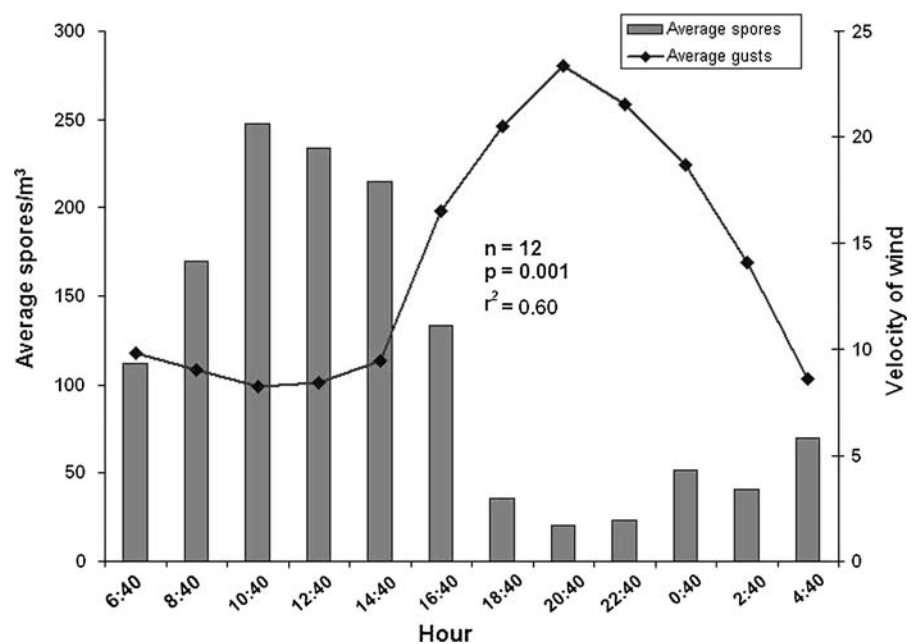


**Fig. 5** Relationship between gusts and total atmospheric spore concentrations. Regression equation is: Average spores =  $274 - 11.5 \text{ Average gust}$ ;  $r^2 = 0.606$



of organic substrates, important for decomposing organisms such as fungi (Levetin and Horner 2002). In contrast, as has been reported in few tropical regions (Hurtado et al. 1989; Chew et al. 2000; Levetin and Horner 2002), and in San Juan, the concentration of spores throughout the year presents a determined seasonal pattern and concentrations that

were more closely related to the precipitation pattern (Burrowes et al. 2004). It has been recognized in multiple studies that meteorological factors could be associated with the increase or decrease in this particulate in the atmosphere (Hurtado et al. 1989; Chew et al. 2000; Levetin and Horner 2002). Although it is difficult to perform a study to

**Fig. 6** Relationship between dew point and total atmospheric spore concentrations. Regression equation is: Average spores  $-17,246 + 826$  Average dew point;  $r^2 = 0.716$

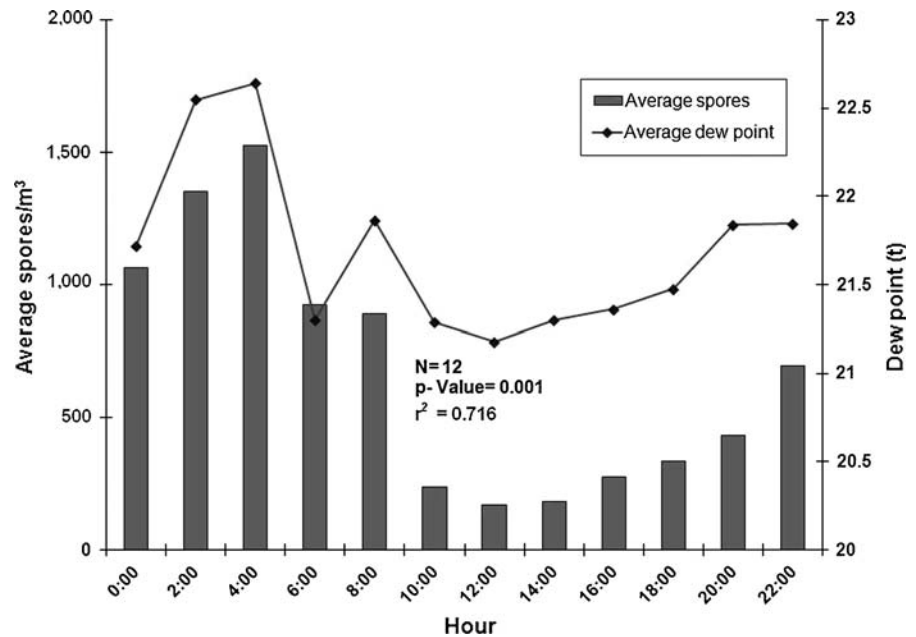
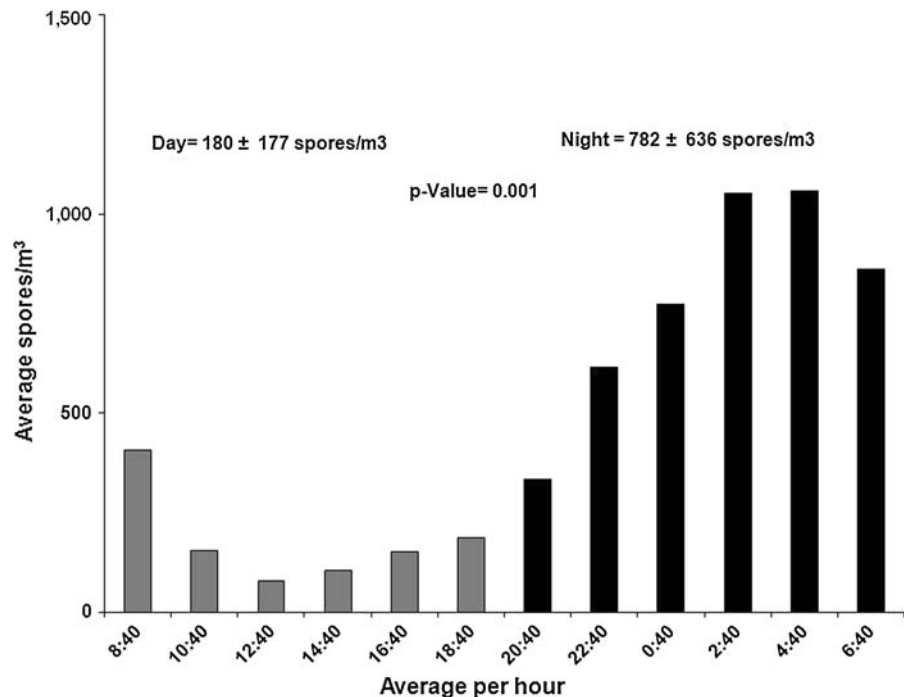
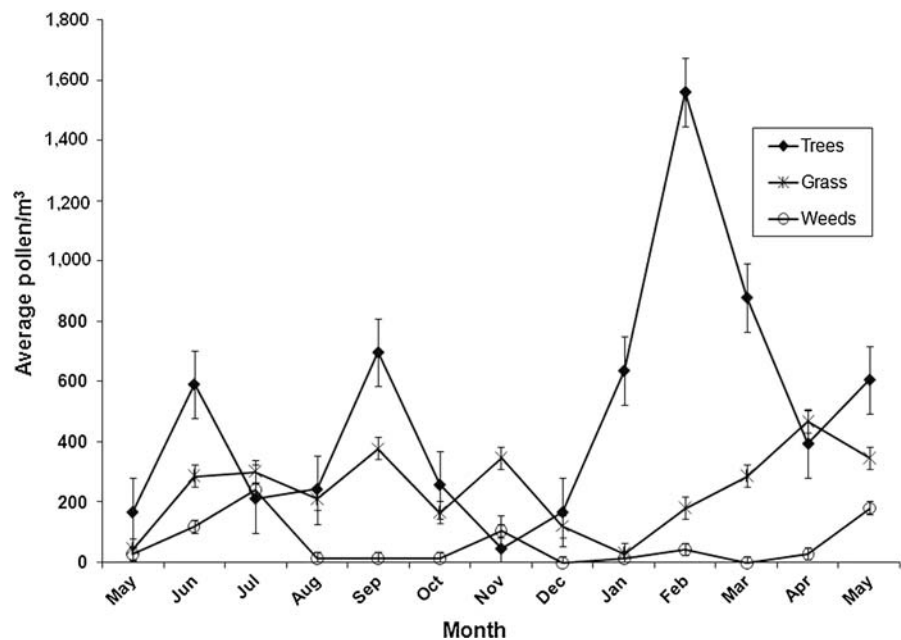


**Fig. 7** Intradiurnal variation in mean fungal spore concentration during a 24-h period in San Juan, Puerto Rico ( $P$  value = 0.001)



determine how the weather affects the abundance of fungal spores in the atmosphere, meteorological phenomena provides a compendium of factors that, in conjunction or individually, could elucidate the factors that increase or lower the aeroallergen load in the environment (Jamason et al. 1997; Homa et al.

2000; Edmondson et al. 2005). In San Juan, the concentration of spores was directly related to the dew point, humidity, and intensity of the wind. The dew point (temperature at which the water vapors present in the atmosphere will condense into water) and gusts were the most significant variants, with dew

**Fig. 8** Distribution annual of pollen for classes

point being important for promoting the release of spores while the wind acting as a dispersing agent and significantly affecting the results as the spore trap we employed, MK3, is not a wind-oriented instrument (Portnoy et al. 2000).

Pollen in San Juan is a fluctuating atmospheric particulate because no significant correlation was observed between pollen counts and the meteorological factors. This may be due to the fact that in the tropics plants may bloom all year long, and there are no seasons of high pollen concentration as opposed to the spring for tree pollen, the summer for grass pollen, and fall for weeds pollen observed in temperate regions. The most common pollens were tree pollens of small size such as *Cecropia* sp. and *Artocarpus* sp. that could be dispersed by the wind. Larger pollens were not detected as these have insects, birds, or bats as the main dispersal agents (Joglar 2008). Pollen from entomophilous plants are usually heavy, large, and with sticky surfaces, attributes that makes them less aerodynamic than pollen from anemophilous plants, which are small, with smooth surfaces, and some even with the presence of air sacs that increase buoyancy in the airflow (Busse et al. 2000).

Most basidiospores and ascospores, which have been mentioned as important allergens in different parts of the world (Mori et al. 1998), require humidity

in order to be released, thus being more common during the night and early morning when the relative humidity increases. On the contrary, other fungi, such as *Cladosporium*, require less amount of humidity for sporulation and, for this reason, their concentration is highest during midday when the humidity is less and the wind is dry (Burge and Rogers 2000; Black et al. 2000; Troutt and Levetin 2001; Burch and Levetin 2002; Levetin and Horner 2002; Okten et al. 2005). The rain, in small amounts, could be a stimulating factor for sporulation and airborne concentration; however, when the intensity of rain increases, it operates by removing spores from the atmosphere: the hydrated spores and those of larger size will be affected by the force of gravity, which leads to lower air concentrations (Burge and Rogers 2000; Chakraborty et al. 2001; Sakiyan and Inceoglu 2003).

Levetin and Horner (2002) have described mechanisms by which the rain could be contributing positively for dry (e.g., *Cladosporium* sp., *Alternaria* sp.) and wet spores (basidiospores, ascospores) concentrations. Dry spores that are often found on the surface of leafs could be dispersed when rain drops hit the leaf, and, although the basidiospores do not necessarily need the rain, it has been observed that mushroom and puffballs tend to develop within days of episodes of intense rain. In the case of ascospores, some follow a similar pattern as with

basidiospores (high concentration in the presence of high humidity), while others are liberated before or after the precipitation. Burge and Rogers (2000) report other mechanisms in which the precipitation of different intensity and humidity could be inducers or repressors of the sporulation, while other studies indicate that electric storms could increase the spore concentration in the atmosphere (Packe and Ayres 1985; Lewis et al. 2000; Denning et al. 2006).

In various regions, fluctuation has been reported in the concentration of spores during the day (Okten et al. 2005), similar to what is observed in San Juan, where the highest concentration of spores is present during the early morning hours, which could be due to high relative humidity during these hours. Finally, many of the fungal spores that are found in the air originate from plant pathogens; in this case, the humidity that exists on the surface of plants could favor the liberation of spores through an evaporation-transpiration process (Gottwald et al. 1997; Burge and Rogers 2000; Levetin and Horner 2002).

The geographical position of Puerto Rico determines the existence of a tropical climate, receiving winds regimes of wind from different latitudes, including those from the northeast of Africa responsible for the episodic intrusions, from April through August, of clouds of Saharan Desert dust and sporadic presence of volcanic ashes from the Soufriere volcano located on the island of Montserrat (in the Eastern Caribbean), both of which have been identified by some to be as able to carry mold spores (Griffin et al. 2001). In the present investigation, the presence of these inorganic particulates corroborated on multiple occasions during the year (April through August), but no correlation was found with the peaks of high fungal spore density given that high and very high fungal spore concentrations were observed in the absence of the Saharan desert dust.

The orographic system of Puerto Rico determines the presence of microclimates that affect the atmospheric dynamism and contribute to the dispersion or concentration of biological particulate. Regardless of the atmospheric fluctuations, the presence of fungal particles in the air of San Juan was constant, reaching higher concentrations than that of pollen. Apparently this is not limited to the tropical regions because some studies have reported that this pattern has been reported in other locations and latitudes of the world, such as in Europe and Singapore (D'Amato and

Spieksma et al. 1995; Chew et al. 2000; Black et al. 2000; Denning et al. 2006).

Studies performed in different countries with temperate climate indicate that spores of *Cladosporium* are the most frequent, followed by others such as *Alternaria*, *Fusarium*, *Aspergillus*, and *Penicillium* (Troutt and Levetin 2001; Sakiyan and Inceoglu 2003); other studies indicate that in tropical regions *Aspergillus* is predominant, while *Penicillium* is present in all the latitudes (Okten et al. 2005). In contrast to these studies, in San Juan basidiospores and ascospores predominated over other spores that are commonly reported in temperate countries, which could be explained by diversity of forest and urban vegetation characteristic of the island, environments in which basidiospores and ascospores are commonly found.

In the field of allergy, knowledge of the behavior of airborne allergens is essential for an etiological diagnosis (D'Amato and Spieksma 1995). The genera of spores identified in the air of San Juan have been reported in several investigations as allergenic or with the potential of being allergenic (Chew et al. 2000; Levetin and Van de Water 2001; Levetin and Horner 2002; Beckett et al. 1996; Newson et al. 2000; Bartra Tomas 2003; Newhouse and Levetin 2004). For this reason, they represent a problem of environmental health, mainly in the area of the island identified by the Puerto Rico Department of Health with the highest incidence of allergies. In the case of pollen, although its concentration and frequency were intermittent throughout the year, their contribution to allergies in our region cannot be disregarded. According to Loyo-Berrios et al. (2006), high prevalence of asthma has been observed in the northeastern area of Puerto Rico, while its prevalence among Puerto Rican children living in Puerto Rico has been reported to be higher than those living in the Bronx (Cohen et al. 2007). If a high proportion of individuals are genetically predisposed to asthma, then the unique tropical and environmental characteristics of Puerto Rico such as the abundance of basidiospores and ascospores detected in this study can have an additive effect that could result in a much higher incidence of asthma (Loyo-Berrios et al. 2006).

Finally, the spore and pollen counts are important tools for characterizing the behavior of aeroallergens that could affect sensitized individuals. In Puerto Rico, where there is no calendar of spores and in

which allergies are treated according to protocols applied in other latitudes without taking into account that this is a tropical island, having information about the presence and abundance of aeroallergens available could assist in the diagnoses of allergic conditions and could lead to the design of preventive measures. Although in the last decades, there has been an increase in the interest to investigate the effect of atmospheric contamination on human health, the role of fungi, and their effect on the respiratory tract still needs to be clarified.

**Acknowledgments** We are grateful to Dr. C. Mariani and Dr. P. Burrowes for their helpful revisions and suggestions.

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