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Thirty-four identifiable airborne fungal spores in Havana, Cuba

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Abstract

The airborne fungal spore content in Havana, Cuba, collected by means a non-viable volumetric methodology, was studied from November 2010 – October 2011. The study, from a qualitative point of view, allowed the characterization of 29 genera and 5 fungal types, described following the Saccardo´s morphotypes, as well as their morphobiometrical characteristics. In the amerospores morphotype, the conidia of 7 genera (with ascospores, basidiospores and uredospores) and 5 fungal types were included. Among phragmospores morphotype, the ascospores and conidia of 12 different genera were identified. The dictyospores morphotype only included conidial forms from 6 genera. Finally, the less frequent morphotypes were staurospores, didymospores and distosepted spores. In general, the main worldwide spread mitosporic fungi also predominated in the Havana atmosphere, accompanied by some ascospores and basidiospores. *Cladosporium cladosporioides* type was the most abundant with a total of 148,717 spores, followed by *Leptosphaeria, Coprinus* and the *Aspergillus-Penicillium* type spores, all of them with total values ranging from 20,591 – 16,392 spores**.** The higher monthly concentrations were registered in January (31,663 spores) and the lowest in December (7,314 spores). Generally, the average quantity of spores recorded during the months of the dry season (20,599 spores) was higher compared with that observed during the rainy season (17,460 spores).

Key words

Airborne fungi, Spores, Non-viable methodology, Havana, Cuba

INTRODUCTION

Environmental mycological studies are of great interest because they can be applied to several fields, from agronomy to cultural heritage conservation (paintings collections, sculptures, buildings), as well as to the prevention of several human allergenic type diseases. During recent years, important studies have been conducted, focused on these aspects in the city of Havana and its environs. In the rural areas, the major phytoparasitic fungus affecting rice crops has been monitored, highlighting the importance exerted by the fungal type *Pyricularia,* among others [1, 2]. The *Cladosporium* and *Aspergillus* types have also been identified as being more common in museums [3, 4] as well as in the houses of the allergic population [5].

For the collection of the fungal spores for the presented study, viable gravimetric or volumetric methods were used, which enable assessment of the amount of colony forming units per cubic meter of air (CFU/m^3). The culture technique is effective for ensuring a specific identification level, as it allows completing a macroscopic colony study and a clear microscopic observation of all structures, both vegetative and reproductive. However, it also has disadvantage that impede a continuous spore monitoring of the spores and it is not possible to determine their hourly behaviour. In this regard, the non-viable analytical methodologies based on Hirst type samplers and visual identification was very useful [6]. They allow the obtaining of data from the behaviour of the airborne spores at different timescales (start-presence periods, peak days, maximum hourly values, etc.), which are extremely important to improve the quality of life of allergic people [7].

The annual continuous study enable the stablishment of annual calendars of spores presence in the air, and to compare their variations between years [8]. However, in order to identify the most interesting types and to study their spatiotemporal patterns, the fungal spore diversity of the atmosphere in the studied area must be ascertained by means qualitative studies and taxonomic clasifications [9].

Objective. The aim of the presented study was to assess the fungal atmospheric spore content in Havana city with a non viable method, and to determine its environmental fungal biodiversity during the period of a complete year. The data obtained could be applied in the prevention and diagnosis of allergic respiratory diseases in Cuba.

MATERIALS AND METHOD

The study was conducted in the city of Havana, located on the northern coast of the island of Cuba. Its climate is subtropical, with a dry season (November – April) and a rainy season (May – October). The average annual temperature is 25.5 °C, the total annual rainfall – 1320 mm, and relative humidity is more than 80% for most of the year. Havana is the biggest and most populated city of Cuba. The vegetation in the proximity of the trap is not dense, and consists of a wide variety of trees, shrubs and ornamental plants.

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The spores detected by direct microscopy were collected by using a volumetric Hirst type sampler (Lanzoni VPPS 2000, Bologna, Italy) located on the roof of the Faculty of Biology at the University of Havana, 35 meters above ground level (23º 08'N and 82º 23' W). Sampling was carried out continuously (operating 24hours/day) during one year, from 2 November 2010 – 31 October 2011. The Lanzoni equipment was calibrated for a 10 air litres per minute flow, and the spores impacted a Melinex tape coated with a 2% silicone solution. The spore count was performed using the methodology proposed by the Spanish Aerobiological Network [6]. Results were expressed as spores per cubic meter (spores/m^3) of air for daily concentrations, and total spores for monthly and annual values.

The spores collected were described considering morphotypes [10, 11] as well as its morphobiometrical characteristics. Its identification was mainly conducted at genera or fungal type level. For this purpose, the reference preparations from the collection of cultivations of the Department of Microbiology and Virology of the University of Havana and specialized bibliography [11, 12], among others, was used.

RESULTS

Fungal diversity. A total of 29 genera and 5 fungal types were characterized (Fig. 1). In the amerospores morphotype the conidia, ascospores, basidiospores and uredospores of 7 genera (*Beltrania*, *Chaetomium*, *Coprinus*, *Ganoderma, Gliomastix*, *Nigrospora* and *Periconia*), as well as 5 fungal types (*Aspergillus/Penicillium* type, *Cladosporium cladosporioides*, *Cladosporium herbarum*, Uredinales and Xylariaceae) were included. Among the phragmospores morphotype, the ascospores and conidia of 12 different genera were identified (*Cercospora, Curvularia, Fusarium, Leptosphaeria, Helicoma, Helicomyces, Paraphaeosphaeria, Pestalotiopsis, Pseudocercospora, Pyricularia, Sporidesmium* and *Torula*). The dictyospores morphotype only included conidial forms from 6 genera (*Alternaria*, *Epicoccum*, *Monodictys*, *Pithomyces, Pleospora* and *Stemphyllium*). Finally, the less frequent morphotypes were staurospores (*Spegazzinia* and *Tetraploa*), didymospores (represented by the *Venturia* genus) and distosepted spores (with only the *Bipolaris* genus). Table 1 shows the main morphological characteristics of each morphotype.

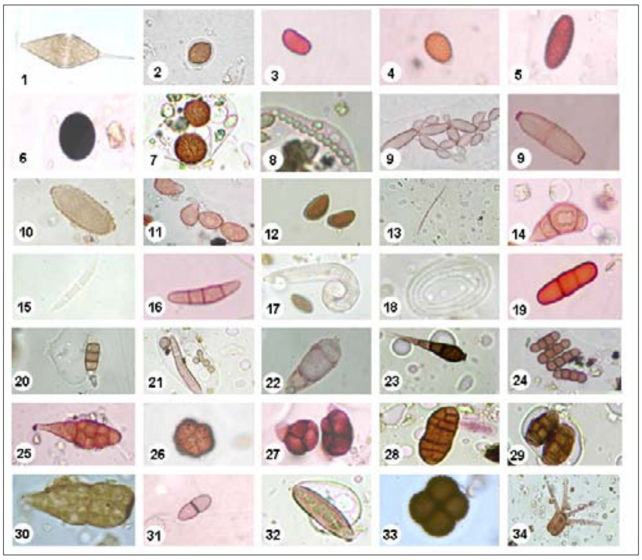

Figure 1. Genera identified from non viable spores (1) *Beltrania*, (2) *Chaetomium*, (3) *Coprinus*, (4) *Ganoderma*, (5) *Gliomastix*, (6) *Nigrospora*, (7) *Periconia*, (8) *Aspergillus/ Penicillium* type, (9) *Cladosporium cladosporioides* type, (10) *Cladosporium herbarum* type, (11) *Uredinales* type, (12) *Xylariaceae* type, (13) *Cercospora*, (14) *Curvularia*, (15) *Fusarium*, (16) *Leptosphaeria*, (17) *Helicoma*, (18) *Helicomyces*, (19) *Paraphaeosphaeria*, (20) *Pestalotiopsis*, (21) *Pseudocercospora*, (22) *Pyricularia*, (23) *Sporidesmiun*, (24) *Torula*, (25) *Alternaria*, (26) *Epicoccum*, (27) *Monodictys*, (28) *Pleospora*, (29) *Pithomyces*, (30) *Stemphylium*, (31) *Venturia*, (32) *Bipolaris*, (33) *Spegazzinia* and (34) *Tetraploa*

Although individually considered, none of these parameters is enough to distinguish one genera form the other spores included in the same morphotype, some particularities could facilitate the identification. Thus, among the amerospores morphotype, the biconoid shape for the *Beltrania* amerospores is important for its recognition, the globose and apiculate extrems for the *Chaetomium* ascospores identification, and the black and spherical form of the *Nigrospora* conidia. Moreover, for the *Gliomastix*, *Ganoderma* and *Periconia* genera, identification of the shape and morphology of the wall has greater importance. The *Cladosporium* conidia were separated into two spore types as result of their wall morphology, being flat for the *Cladosporium cladosporioides* type and warty in the *Cladosporium herbarum* type. The conidiogenesis of this genus explains the morphological variability of the conidia with 1 – 3 septum. Otherwise, the conidia of the *Aspergillus/Penicillium* type are one of the smallest in size with a hyaline, grey, blue or green colour, and they can appear solitary or in chains. The ascospores of the Xylariaceae type are easily recognized by their elongated longitudinal fissure. The uredospores of the *Uredinales* type are distinguished by their reddish-orange colour and rough ornate wall. *Coprinus* basidiospores were easily identified by the presence of a germ pore at one extreme.

The phragmospores morphotype is one of the most common in the air. Among them, more or less thick and long filamentous forms (*Cercospora*, *Pseudocercospora*, *Fusarium* and *Pestalotiopsis*), spirally forms (*Helicoma* and *Helicomyces*), long chains of small spherical celled conidia (*Torula*) and forms with one cell higher than the rest (*Curvularia*, *Pyricularia*, *Sporidesmium*, *Leptosphaeria* and *Paraphaeosphaeria*) were included.

Regarding the identification of the dictyospores morphotype, the *Alternaria* genus was characterized by their muriform aspect and longer peak, which is always shorter if it is present in the *Stemphylium* spores. *Pithomyces* spores are characterized by their truncated apex conidia which allow its differentiation from *Pleospora*, a genus that presents an equatorial constriction. The rough wall that forms irregular patches in the *Epicoccum* conidia allows its differentiation from the brown to black colour *Monodictys* conidia. Finally, the spores included in the *Spegazzinia*, *Tetraploa*, *Venturia* and *Bipolaris* genus presented difficulty with recognition as a consequence of their conidia morphology.

Temporal dynamics. During the study period, a total of 496,017 spores were observed. Of these, 45.9% were characterized and identified at genus or spore type level. Table 2 shows the genera and spore types with an annual total amount higher tham 1,000 spores. The *Cladosporium cladosporioides* type was the most abundant with a total of 148,717 spores, followed by the *Leptosphaeria*, *Coprinus* and *Aspergillus-Penicillium* types, all of which reached

Genus/Type	Morphotype/Size	Color	Shape/Wall	Other characteristics
Beltrania Penzig.	Amerospores 24-28x9-10µm	Brown	Biconic/Smooth	Paler middle band
Chaetomium Kunze	Amerospores 9-15µm	Brown	Lemon-shaped/Smooth	Wall sometimes rugose
Coprinus Pers.	Amerospores 7-22x4-13µm	Dark brown	Ovoid to ellipsoid /Smooth and thick	Germinative pore on the tip
Ganoderma Karst.	Amerospores 6-12x4 -8µm	Orange	Ovoid to ellipsoid/External wall smooth, intemal thick and ornamentated	Truncated apex
Gliomastix Gueg.	Amerospores 6-18x5-9µm	Brown	Ovoide or ellipsoid/Rugose	
Nigrospora Zimm.	Amerospores 12-15µm	Black	Spherical/Smooth	
Periconia Tode	Amerospores 10-22 µm	Brown	Spherical to sub-spherical/ verrucose to echinulated	
Aspergillus/ Penicillium type	Amerospores 2-6µm	Hyaline or brightly colored	Spherical to sub-spherical/ Smooth or rough	Solitary or in chains
Cladosporium cladosporioides type	Amerospores 3-15x2-6µm	Hyaline to olivaceous light	Ellipsoid or lemon-shaped/Smooth	1- or 2-celled, Solitary or in chains
Cladosporium herbarum type	Amerospores 8-25x4-8µm	Light brown or olivaceous	Ellipsoid, oblong/ Thick, verrucose	1- or 2-celled, Solitary or in branched chains
Uredinales type	Amerospores 20-30µm	Orange-red	Globose/Rough	Sometimes ornamentated walls
Xylariaceae type	Amerospores 2-4x9-15µm	Dark brown	Ellipsoid/Smooth	Longitudinal fissure lengthened, coiled or poroid
Cercospora Fres.	Phragmospores 20-100µm	Hyaline or gray	Cylindrical to filiform/Smooth or rough	Several-celled
Curvularia Boedijn	Phragmospores 30-35x18-29µm	Brown, end cells lighter	Straight o curved/Smooth or rough	Hilum and 3- to 5-celled. Central cell enlarged
Fusarium Link	Phragmospores 3-5x30-60µm	Hyaline	Typically canoe-shaped/ Smooth and thin	Macroconidia several-celled
Leptosphaeria Ces. & De Not.	Phragmospores 10-150x5-10µm	Hyaline to light brown	Fusiform/Smooth	4- to 9-celled, basal cell enlarged. Septal constrictions
Helicoma Corda	Phragmospores 17-2µm	Hyaline to brown olivaceous	Coiled/Smooth	5- to 12-septate
Helicomyces Link	Phragmospores 150-160x4-6µm	Hyaline	Conidial filaments thin/Smooth	Tightly coiled in one plane
Paraphaeosphaeria Erik.	Phragmospores 12-22µm	Light orange to brown	Cilindrica/Rough	Pointed and bigger end cells. One septal constriction
Pestalotiopsis Steyaert	Phragmospores 13-21µm	Brown, apical cells hyaline	Ellipsoid to fusoid/Smooth	5 celled, pointed end cells. Two or more hyaline, apical appendages
Pseudocercospora Speg.	Phragmospores 30-70x5-6µm	Brown	Conical or truncated to the Hilum/Smooth or rough	Fine scar
Pyricularia Sacc.	Phragmospores 24-29x10-15µm	Hyaline	Obpyriform /Smooth	Hilum protuberant and truncated
Sporidesmium Link	Phragmospores 25-40x10-14µm	Brown	Obclavate to long, fusoid/Smooth	Several celled
Torula Pers.	Phragmospores 4-6µm	Dark brown	Spherical-cilindrical/Smooth or rough	1- to several-celled, cells rounded, dark, in acropetalous chains
Alternaria Nees	Dictyospores 15-30x12-27µm	Brown, pale brown	Variously shaped/Smooth or rough	Obclavate to elliptical or ovoid
Epicoccum Link	Dictyospores 19-25µm	Brown to red brown	Spherical/Rough	Basal cell paller and distinguible
Monodictys Hughes	Dictyospores 15x30µm	Brown to black	Oblong, subspherical or irregular/Smooth or rough	Denticulated on the base, globose, oblong at the appex
Pleospora Rabenh. ex Ces. & De Not.	Dictyospores 16-30 µm	Brown to olivaceous	Elliptic, globose, ovoid, pointed end cells/Smooth o rough	Central cells protuberant, strong central constriction
Pithomyces Berk. & Broome	Dictyospores 4-15x6-25µm.	Yelowish to dark brown	Ellipsoid, lemon shaped, ovoid, piriform/ Smooth, echinulated or rough	Constricted at one or more septum and basal scar
Stemphylium Wallr.	Dictyospores 20-80µm	Pale brown or olivaceous	Ellipsoid or ovoid, conical and pointed end cell/Smooth, rough or echinulated	Granules or irregular patches
Venturia Sacc.	Didymospores 9-20x3-7µm	Yellowish to light brown	Ellipsoid/Smooth	One cell shorter and wider
Bipolaris Schoemaker	Distosepted 20-60x6-15µm	Brown	Elliptic, straight/Smooth or rough	
Spegazzinia Sacc.	Staurospores 12- 30 µm	Brown	Paged/Smooth or spiny	4 or 8 muriform cells
Tetraploa Berk. & Broome	Staurospores 25-39x14-29µm	Brown	4 long, attenuated, septate appendages/ Smooth o rough	Muriform, superficial furrows

Table 2. Concentration, daily mean and maximum, and date of maximum of the most abundant fungal types identified

	Total spores	Daily mean (spores/m^3)	Daily maximun (spores/m^3)	Date of maximum
Cladosporium cladosporioides type	148717	409	4330	26-may
Lepthosphaeria	20591	57	363	19-oct
Coprinus	17244	47	880	30-sep
Aspergillus-Penicillium type	16392	45	384	11-apr
Curvularia	3286	9	148	24-sep
Nigrospora	2557	7	63	20-jan
Periconia	2311	6	91	20-jan
Cladosporium herbarum type	1982	5	116	21-jan
Gliomastix	1895	5	88	06-nov
Ganoderma	1446	4	44	04-sep
Alternaria	1396	4	56	02-oct
Bipolaris	1338	4	76	30-jun
Uredinales type	1238	3	87	28-dec
Fusarium	1150	3	40	28-aug
Monodictys	1052	3	107	28-nov

concentrations between 20,591 – 16,392 spores. The daily mean and daily maximum concentrations presented similar behaviour. However, the daily peaks registered by *Curvularia* (148 spores/m^3 on 24 September), the *Cladosporium herbarum* type (116 spores/m^3 on 20 January) and *Monodictys* (107 spores/m^3 on 21 January), should also be highlighted, although these genera are considered as secondary from a quantitative point of view, according to their annual total values.

Regarding the annual distribution (Fig. 2), in the month of January were recorded the highest total quantity of spores (31,663) and in December the lowest (7,314). In general, the average of the spore amount recorded was higher during the months of the dry season (20,599 spores) compared to the rainy season (17,460 spores). The *Cladosporium cladosporioides* type showed a higher abundance during the months of January and April (24,591 and 23,218 spores,

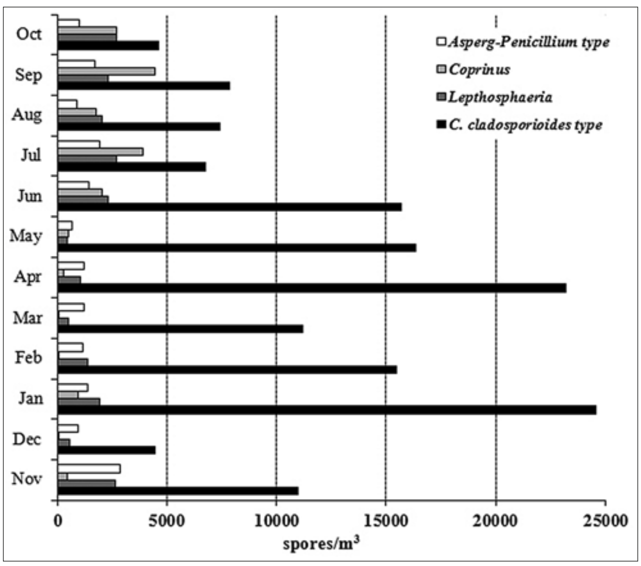

Figure 2. Fungal types most abundant in the atmosphere of Havana

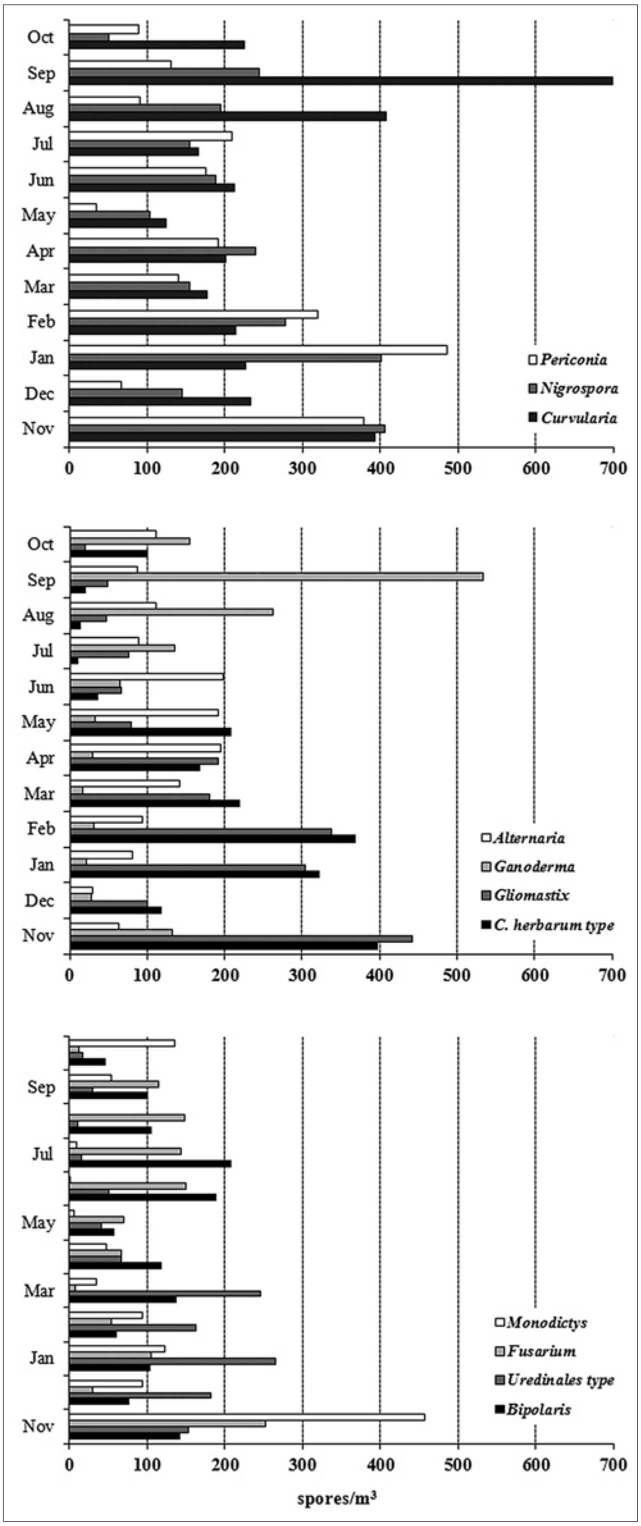

Figure 3. Secondary fungal types identified in the atmosphere of Havana

respectively), with important values also registered during February, May and June. *Leptosphaeria* and *Coprinus* had a higher incidence during the rainy season months (maximum values were observed in July and September, with 2,726 and 4,434 spores, respectively), and the *Aspergillus/Penicillium* type reached the maximum concentrations during November (2,888 total spores).

Among the fungal types considered as secondary from a quantitative point of view (Fig. 3), the *Periconia*, *Curvularia* and *Nigrospora* genera had monthly concentrations of about 200 spores, the *Alternaria*, *Ganoderma*, *Gliomastix* and *Cladosporium cladosporioides* type about 150 spores, while *Monodictys*, *Fusarium*, *Bipolaris* type and *Uredinales* type registered monthly values of about 100 spores. However, it should be highlighted that the monthly maximum values obtained for the *Ganoderma* and *Curvularia* spores were during the month of September (699 and 534 spores, respectively) and 458 spores registered by *Monodyctis* in November.

Finally, other minoritary genera with total annual values lower than 1,000 spores included mitosphoric (*Beltrania, Cercospora, Epicoccum, Helicoma, Helicomyces, Pestalotiopsis, Pithomyces, Pseudocercospora, Pyricularia, Spegazzinia, Sporodesmium, Stemphylium, Tetraploa, Torula*) and Ascomycete (*Chaetomium, Paraphaeosphaeria, Pleospora, Venturia* and Xylariaceae type) fungus.

DISCUSSION

The spore distribution is not constant across the earth's atmosphere. The more common fungi in the temperate regions are not necessarily prevalent in the tropics [13]. Therefore, this is the first attempt to characterize the mycobiota of the air of Cuba by means of volumetric non-viable methods in order to identify the more important spore types and to determine their spatio-temporal patterns.

The use of non-viable volumetric methods presents unquestionable advantages in the studies of environmental mycology; however, the fungal identification could hardly ever be achieved at species level. Another aspect that limits the recognition of the spores is the difficulty in discriminating between sexual and asexual spores when both have similar aspects [7]. Nevertheless, in the presented study it was possible to recognize different genera from Ascomycetes (*Chaetomium*, *Leptosphaeria*, *Paraphaeosphaeria*, *Pleospora* and *Venturia*), Basidiomycetes (*Coprinus* and *Ganoderma*) and anamorphic fungi (*Alternaria, Beltrania, Bipolaris, Cercospora, Curvularia, Epicoccum, Fusarium, Gliomastix, Helicoma, Helicomyces, Monodictys, Nigrospora, Periconia, Pestalotiopsis, Pithomyces, Pseudocercospora, Pyricularia, Spegazzinia, Sporidesmium, Stemphylium, Tetraploa* and *Torula*). Previous studies based on visual identification only reported the presence of *Leptosphaeria* ascospores and some mitospores in the Cuban atmosphere [14]. However, in the current study, the continuous presence of ascospores and basidiospores in the bioaerosol was discovered throughout the year [13], spores which induce more allergic sensitizations than the mitospores [15]. Hence, several researchers have used the concept of 'morphotype' or 'spore type' to define a spore group which share similar morphology, independent of whether the fungus belongs or not to the same genus [16, 7]. In this paper, five spore types were defined (*Aspergillus/Penicillium*, *Cladosporium cladosporioides*, *Cladosporium herbarum*, Xylariaceae and Uredinales).

The average number of spores registered was higher during the months of the dry season than in the rainy season, with the highest concentrations being the types *Cladosporium cladosporioides*, *Leptosphaeria, Coprinus* and *Aspergillus-Penicillium*. The high incidence of the *Cladosporium, Aspergillus* and *Penicillium* spores has been cited by other authors in Cuba [17, 1], as well as the important *Leptosphaeria* values [14]. In México, the *Cladosporium* were registered throughout the year, whereas the high *Aspergillus* and *Penicilllium* concentracions were observed during the winter [18]. Its presence has also been reported in other tropical and subtropical regions [19].

The *Cladosporium cladosporioides* type and *Cladosporium herbarum* type are conidia oblong, ellipsoid, or fusiform with truncate end, light olive, with a prominent, protuberant dark scar at each end. However, the *Cladosporium cladosporioides* type groups of conidia are predominantly limoniform, ellipsoid and smooth, while the *Cladosporium herbarum* type clusters of conidia are globose, subglobose and minutely verrucose. Each sporal type composed by some species is impossible to distinguish based on the spore shape. Some of the species grouped in the *Cladosporium cladosporioides* type are *Cladosporium cladosporioides, Cladosporium oxysporum* and *Cladosporium tenuissimum,* among others. The species *Cladosporium herbarum*, *Cladosporium sphaerospermum* and *Cladosporium macrocarpum* are included in the *Cladosporium herbarum* type [20].

Cladosporium is a cosmopolitan genus of worldwide atmospheric mycobiota content [20]. Its presence has been previously reported in Cuba [14, 1], but this is the first time that the two afore-mentioned spore types were defined and identified in Cuba by non-viable methods. A predominance of *Cladosporium cladosporioides* type was detected over *Cladosporium herbarum* and over the rest of the genera or spore types detected, based on its high concentrations during the year. The importance for the identification and the monitoring of both types are shown by the allergenic character of their spores. In addition, many *Cladosporium* species are recognized as plants, animals or human pathogens, and their important role in the deteriorating processes of manufactured goods, monuments, paintings and murals has been proved [21].

The genus *Lepthosphaeria* (ascospore) and *Coprinus* (basidiospore) also showed significant concentrations (20,591 and 16,392 spores) prevailing in the rainy months. In tropical environments, sensitization to airborne basidiomycetes, ascomycetes, and fungal fragments seems to be more prevalent than sensitization to mitospores in subjects with active allergies, suggesting a possible role in exacerbations of respiratory allergies [22].

The *Aspergillus/Penicillium* spore type embraces small hyaline amerospores, sometimes in chains without ramifications, and it was impossible to differentiate between genera [23]. Other studies have used the term Aspergillaceae to group this spore type [24]. Their presence has been previously reported in the outdoor Cuban atmosphere by a non-viable method [14] and in indoor studies by cultured-based methods [3, 4]. This spore type has been also detected in the atmosphere of other tropical countries with high concentrations influenced by dryness [25]. In the presented study, the main concentration peak was obtained in this season (2,888 spores in November).

One of the secondary fungal types detected is the Uredinales type, which has thick-walled, yellowish pigmented rust spores that includes aeciospores and uredospores. These spores are often ornamented, with variable dimensions and morphology. Quintero et al. [13] reports the presence of this group in other Caribbean countries, while other authors state that this spore type is only identifiable by means of non-viable samples [23]. Rust spores differentiation is important and definitely should not be grouped into basidiomycetous spores, because rusts are plant pathogens and most basidiospores are fungi of saprobes or ectomycorrhyza. However, the spores of *Ganoderma* were detected with similar annual concentrations. Otherwise, the diversity of species of the *Fusarium* genus has been previously documented in the characterization of the Havana atmosphere or in a rural area near to the Havana [1], as the genus *Curvularia* and *Bipolaris*. The *Bipolaris* genus is characterized by its distosepted and pigmented phragmoconidia. Its differentiation from *Exerohyllum*, *Helminthosporium* and *Curvularia* is a highly complex taxonomic feature. The spores of *Alternaria* have been reported in other parts of the world, and *Nigrospora* propagules has been found mainly in Cuban aerobiological indoor studies [4]. Although its concentrations were not so high, in this year *Alternaria* over *Nigrospora* predominated.

Finally, spores from several minority genera were observed (with annual total values above 1,000 spores), mainly comprised by mitosporic saprophytes fungus which probably came from vegetation near the study area. Among the ascomycetes sporadically detected, the Xylariaceae type is defined as ellipsoid, flat and brown amerospores with a longitudinal fissure elongated, spiral or poroide. Within this family can be found the *Xylaria* genus, the airborne presence of which has been reported in Portugal [24].

CONCLUSIONS

This study constitutes a significant contribution to the determination of the biodiversity and the concentrations of the airborne spores of Havana city. Several of the airborne fungal spores characterized are considered as allergenic for sensitized people. Thus, the monitoring of these spores may be an useful tool for improving human health in the most populated and industrialized city of Cuba, allowing avoidamnce the exposure of sensitive people in periods with high atmospheric spore concentrations and the optimization of the medical treatments. This paper was based in one annual investigation, however further studies over a longer period of time are needed to provide a more knowledge about the temporal dynamics of these thirty-four identifiable airborne fungal spores as well as the influence exerted by the climate or the anthropic activity on their concentrations.

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