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AIRBORNE FUNGI IN THE CITY OF ARACAJU, SERGIPE, BRAZIL

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ABSTRACT

In the present study airborne fungi are reported from the city of Aracaju, Sergipe. Sabouraud agar plates were exposed in 36 boroughs, incubated and cultured. Twenty-six genera were identified. *Aspergillus*, *Botryodiplodia* and *Curvularia*, were the most common, whereas 14 genera were recorded in only one of the four main zones of the city. The incidence of airborne fungi in Aracaju was relatively low, probably due to the local climate and minor industrial pollution.

Key words: airborne fungi, urban environment, Aracaju, Sergipe.

RESUMO

No presente estudo são registrados fungos anemófilos na cidade de Aracaju, Sergipe. Placas de Petri com ágar-Sabouraud foram expostas em 36 bairros da cidade, e incubadas até o crescimento das colônias. Foram identificados vinte e seis gêneros. *Aspergillus*, *Botryodiplodia* e *Curvularia* foram os mais frequentes, enquanto 14 gêneros foram registrados numa das quatro zonas principais da cidade. A incidência de fungos anemófilos em Aracaju foi considerada baixa, possivelmente devido ao clima local e pouca poluição industrial.

Palavras-chave: fungos anemófilos, áreas urbanas, Aracaju, Sergipe.

INTRODUCTION

An important component of environmental pollution, airborne fungi are highly mobile, and are able to disperse rapidly through the atmosphere, depending on climatic conditions. Air temperature and humidity, and the direction and velocity of winds have a direct influence on the production and dissemination of spores, which are a major cause of respiratory diseases in humans (Homrich, 1961).

There is a very strong link between airborne fungi and respiratory allergies, which has prompted epidemiological studies of air quality throughout the World, in an attempt to determine the exact nature of the relationship between the types and quantities of spores in the air, and the prevalence of allergies in a given location (Menezes *et al*., 2004). Despite these efforts, relatively few studies are available for Brazilian

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cities, which limits the analysis of the influence of fungal allergens on local rates of disorders such as asthma and allergic rhinitis (Mezzari *et al*., 2002).

Lima (1941) found that the spores of relatively common airborne fungi, such as *Alternaria*, *Aspergillus*, *Helmintosporium*, *Mucor* and *Penicillium*, constitute an important group of allergens of the respiratory system in many countries. Obviously, reliable knowledge of the abundance and diversity of the local airborne fungal flora is fundamental to the evaluation of allergy patterns and the development of healthcare strategies within a given area (Mendes, 1989; Menezes *et al*., 2006).

With these considerations in mind, the present study analyzed the incidence of airborne fungi in the northeastern Brazilian city of Aracaju, capital of the state of Sergipe. An ample variety of genera were recorded, many of which are prominent allergens, although overall frequencies were relatively low in comparison with many other Brazilian cities, possibly because Aracaju is less heavily industrialized and polluted, and has relatively good climatic conditions for the dispersal of spores.

METHODS

Study Area: The city of Aracaju (Figure 1), capital of the state of Sergipe, is located at the mouth of the River Sergipe (10º54' S, 37º02' W). The municipality has a total area of 174 km², and approximately 520,000 inhabitants (IBGE, 2008). The city has a megathermic climate, with a moderate hydrological deficit during the summer months (September to February). Annual precipitation is around 1600 mm, and mean temperature 26ºC (IBGE, 2000). Climatic parameters for the study period (Table1) were consistent with the season. Once part of the coastal Atlantic Forest, the study area now consists of a typical urban landscape, with abundant mangrove swamps along riverbanks.

Collection and identification of samples: For the collection of a representative sample of the city, in addition to possible local variation, samples were collected in each of the city's 36 neighborhoods, which were arranged for analysis in four geographic zones (Figure 1). All samples were collected at open-air public locations, such as bus terminals and parks.

Two Sabouraud agar plates were exposed simultaneously at each location, 50 cm above the ground, for 15 minutes at mid-morning, between November 2002 and February 2003. Samples were collected on clear or, at most, partially cloudy days. Once exposed, plates were sealed and taken to the Immunology Laboratory of the Federal University of Sergipe, where they were incubated at room temperature (29ºC ± 2ºC) with a 12-hour photoperiod for 4 or 5 days. The resulting fungi were transferred to culture medium for growth, and identified under the microscope according to the available literature (Barnett & Hunter, 1960; Lacaz, 1973; Mendes, 1989).

RESULTS AND DISCUSSION

A total of 26 genera of airborne fungi were identified (Table 2), although almost a quarter of the plates also contained colonies which could not be identified reliably because of the lack of reproductive structures. As in other Brazilian cities (Homrich, 1961; Lima *et al.*, 1963; Buck & Gambale, 1985; Oliveira *et al*., 1993), the table is characterized by relatively high frequencies of a few, more common genera, referred to as "universal dominants" by Morrow *et al.* (1964).

The genus *Aspergillus* was by far the most common genus, appearing in more than half the plates, in comparison with less than 40% in any other genus. *Aspergillus* is an opportunistic taxon which causes pulmonary aspergillosis, a disease of the respiratory tract. Other common genera include *Botryodiplodia* and *Curvularia*, which are known (Lacaz *et al.*, 1984) to cause pheohyphomycosis, a general term which applies to systemic or subcutaneous mycoses observed in humans or animals, characterized by darkened, septated mycelia. *Curvularia* may also invade a host's tissue, resulting in a morbid state similar to those observed in some forms of aspergillosis

(Jawetz *et al.*, 1991). The fourth most common genus – *Monotospora* – does not appear to be important as a pathogen.

The main results of this study are very similar to those obtained in Presidente Prudente, state of São Paulo (Buck & Gambale, 1985), where *Aspergillus* was also recorded in more than half of samples (55.8%). At this site, both *Aspergillus* and *Penicillium* were most common in the wet season. However, the former is present throughout the year (Carvalho & Rios, 1982), causing chronic, continuous and perennial asthma. A predominance of *Aspergillus* was also recorded in other Brazilian cities, such as Natal, Rio Grande do Norte (65.0%: Oliveira *et al.*, 1993), and Fortaleza, Ceará (44.7%: Menezes *et al*., 2006), both of which have climates very similar to that of Aracaju.

One major difference in comparison with Presidente Prudente is the relative scarcity of *Cladosporium* in the present study (one record), whereas the genus was recorded frequently (74.3%) in the former city. Lima *et al.* (1963) recorded a clear seasonal pattern in the occurrence of this fungus in Rio de Janeiro, and its relatively reduced frequency in the present study is likely due to the period of collection, given that dry season conditions – low humidity and precipitation – are generally inhibitive to the growth of fungi (Gambale *et al.*, 1983).

An overview of the results (Table 3) points to marked differences among city zones in the diversity of airborne fungi. While the absolute values were similar, the Central zone appeared to have a much more diverse community of airborne fungi, with 14 genera identified from 12 samples (1.2 per sample), in comparison with only 0.6-0.8 in the other zones. In addition to this recorded diversity, half of the plates contained unidentified colonies, in comparison with 4-33% in the remaining zones, which suggests that the actual variety of genera in this zone may even have been underestimated relative to the other zones. A similarly high rate of exclusive genera was also recorded in comparison with other zones, especially the North. By contrast, the Western zone was distinct in terms of the elevated number of genera collected per sample, in other words, its relative abundance of fungi.

Perhaps surprisingly, some of the exclusive genera were among the most frequently-recorded in their respective zones (Table 4). In the Northern zone, for example, *Gliocladium* was identified in almost a third of samples, and was the fourth most frequently recorded of the twelve genera recorded in this zone. Similarly, both *Staphylotrichum* and *Trichosporonoides* were recorded in a quarter of the samples collected in the Central zone, a proportion second only to *Monotospora*. Most other exclusive genera were recorded only once or twice, however, which suggests that their appearance in the sample of one or other zone may have been determined primarily by random factors, rather than a markedly localized distribution.

One major environmental difference among zones may be their proximity to bodies of water and mangrove swamps, given that the North, South and Central zones are all located along the edges of either rivers, the coastline or both (Figure 1), in contrast with the Western zone, which is located further inland. It remains unclear, however, whether, or to what extent this difference may have affected the results. One possibility is that this zone is less exposed to the prevailing winds, which blow almost invariably from the Atlantic Ocean, to the east. This may explain the greater abundance of colonies in this zone, which are less likely to disperse on the wind. These same winds might also be expected to carry fungi primarily from the Central zone to the West, although the data (Table 3) do not indicate any greater similarity between these two zones in comparison with the others.

The relatively high frequencies of colonies recorded in the Western zone, especially of the more common, allergenic genera such as *Aspergillus*, *Botryodiplodia* and *Curvularia* suggest that the local population may be more vulnerable to respiratory allergies or mycoses. In this context, a complementary analysis of allergy and infection rates in the populations of the different zones could provide useful insights into the etiology of these medical problems, although this is beyond the scope of the present study.

Overall, the results of the present study indicate that Aracaju is most similar to Natal (05º46'S, 35º12'W), which is not only the geographically nearest city for which reliable data are available (Table 5), but also comparable to Aracaju in terms of size, coastal location and industrialization. Further west, along the northern coast of Brazil, Fortaleza (03º43'S, 38º32'W) is also relatively similar, but differentiated by generally much lower frequencies. By contrast, the incidence of airborne fungi appears to be much higher in the more industrialized cities of the Brazilian Southeast, such as Presidente Prudente (22º07'S, 51º23'W) and São Paulo (23º32'S, 46º38'W), where relatively high values were recorded for a much wider range of genera (Table 5).

Supporting this hypothesis, Schoenlein-Crusius *et al*. (2001) recorded a significant increase in the incidence of airborne fungi in the nearby city of Cubatão (São Paulo) during periods of increased atmospheric pollution. While the incidence of fungi recorded in this study was relatively high, the results are not directly comparable with those presented here, because the fungi were identified to species.

Much further south, in the city of Porto Alegre (30º01'S, 51º13'W), airborne fungi appear to be relatively rare, in terms of both diversity and abundance. As this city is at least as large as the others mentioned here (Table 5), it seems possible that its much cooler subtropical-temperate climate may be an important factor.

Overall, the factors determining observed contrasts among cities are difficult to interpret for a number of reasons, in particular methodological differences, which include the sampling effort, period and taxon identification. Given the potential importance of understanding the incidence of airborne fungi, especially allergenic forms, there is a clear need, not only for studies of a much larger number of Brazilian cities, but also the standardization of data collection procedures, with regard to sample size, period, and data analysis.

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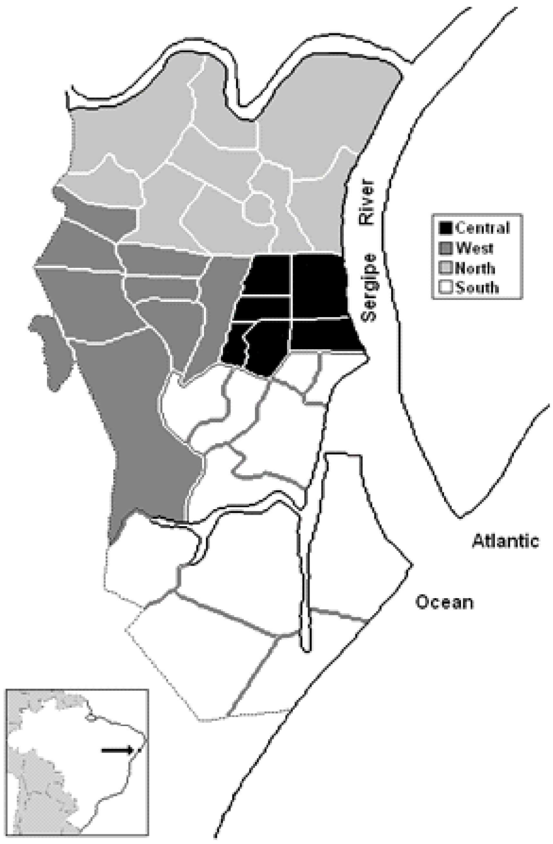

Figure 1. City of Aracaju: division of the 36 boroughs into the four zones analyzed in the present study.

Table 1. Climatic parameters for the study period, November 2002 to February 2003 (source: INFRAERO, Sergipe).

Month	Relative humidity (%)	Temperature (ºC)	Total precipitation (mm)
November	57-100	24.0-31.4	40.7
December	62-93	24.0-31.6	7.6
January	61-91	24.8-31.4	13.1
February	62-96	23.2-31.2	99.7

Table 2. Absolute and relative frequencies of airborne fungi in Aracaju, Sergipe, 2003.

Genus	Number of colonies	% of plates (N = 72)
Aspergillus	37	51.3
Botryodiplodia	27	37.5
Curvularia	24	33.3
Monotospora	20	27.7
Geotrichum	15	20.8
Penicillium	14	19.4
Fusarium	13	18.0
Helminthosporium	12	16.0
Candida	8	11.1
Oidiodendron	7	8.3
Gliocladium	6	8.3
Neurospora	4	5.5
Pullularia	4	5.5
Staphylotrichum	3	4.1
Trichosporonoides	3	4.1
Trichocladium	3	4.1
Alternaria	2	2.7
Microsporum	2	2.7
Mycotypha	2	2.7
Nigrospora	2	2.7
Trichoderma	2	2.7
Colletotrichum	2	2.7
Acremonium	1	1.3
Cephalosporium	1	1.3
Cladosporium	1	1.3
Papularia	1	1.3
Unidentified	17	23.6

Table 3. Comparação entre as zonas de Aracaju e as porcentagens de fungos que ocorreram em cada zona. Aracaju – SE, 2003.

Zone	Samples	Genera identified	Exclusive genera (found only in this zone)	Mean number of genera per sample
North	20	12	2	3.0
South	22	15	5	2.8
West	18	15	4	4.2
Central	12	14	4	2.8

Table 4. Absolute and relative frequencies of colonies of the different airborne fungus genera by zone of Aracaju.

Genus	Number (%) of colonies in zone:			
	North	South	West	Central
Aspergillus	16 (80.0)	9 (50.0)	9 (50.0)	3 (25.0)
Botryodiplodia	3 (15.0)	23 (59.0)	10 (55.5)	1 (8.3)
Curvularia	7 (35.0)	7 (31.8)	9 (50.0)	1 (8.3)
Monotospora	2 (10.0)	3 (13.6)	8 (44.4)	7 (58.3)
Geotrichum	4 (20.0)	6 (27.2)	4 (22.2)	1 (8.3)
Penicillium	4 (20.0)	1 (4.5)	8 (44.4)	1 (8.3)
Fusarium	7 (35.0)	2 (9.0)	2 (11.1)	2 (16.6)
Helminthosporium	2 (10.0)	5 (22.7)	5 (27.7)	-
Cândida	3 (15.0)	-	3 (16.6)	2 (16.6)
Oidiodendron	-	7 (31.8)	-	-
Gliocladium	6 (30.0)	-	-	-
Neurospora	-	1 (4.5)	2 (11.1)	1 (8.3)
Pullularia	-	-	3 (16.6)	1 (8.3)
Staphylotrichum	-	-	-	3 (25.0)
Trichosporonoides	-	-	-	3 (25.0)
Trichocladium	-	-	3 (16.6)	-
Alternaria	2 (10.0)	-	-	-
Microsporum	-	2 (9.0)	-	-
Mycotypha	-	2 (9.0)	-	-
Nigrospora	-	2 (9.0)	-	-
Trichoderma	-	-	2 (11.1)	-
Colletotrichum	1 (5.0)	1 (4.5)	-	-
Acremonium	-	1 (4.5)	-	-
Cephalosporium	-	-	1 (5.5)	-
Cladosporium	-	-	-	1 (8.3)
Papularia	-	-	-	1 (8.3)
Unidentified	4 (20.0)	1 (4.5)	6 (33.3)	6 (50.0)
Number of plates	**20**	**22**	**18**	**12**

Table 5. Most common airborne fungi (>10% of plates) recorded in the present study and five other Brazilian cities.

Genus	% of plates in[1]: Aracaju	Fortaleza	Natal	Porto Alegre	São Paulo	Presidente Prudente
Aspergillus	51.3	44.7	65.0	15.0	23.3	55.8
Botryodiplodia	37.5	-	-	-	-	-
Curvularia	33.3	9.8	15.8	0.9	7.7	10.2
Monotospora	27.7	-	-	-	-	1.3
Geotrichum	20.8	0.2	0.8	-	0.9	0.6
Penicillium	19.4	13.3	50.0	15.0	41.7	17.9
Fusarium	18.0	3.5	20.8	0.1	14.0	26.9
Helminthosporium	16.0	-	-	2.5	9.3	2.7
Candida	11.1	-	-	-	14.7	20.5
Cladosporium	1.3	6.8	17.5	17.8	64.8	74.3
Rhizopus	-	3.1	14.1	-	1.9	26.9
Rhodotorula	-	0.9	10.8	-	48.9	22.4
Epicoccum	-	0.4	-	-	51.7	16.0
Monascus	-	-	-	-	-	44.2
Aureobasidium	-	-	-	-	19.6	37.2
Neurospora	5.5	1.4	7.5	-	4.4	35.9
Trichoderma	2.7	0.1	3.3	-	11.2	24.4
Mucor	-	0.4	1.6	-	1.4	17.3
Alternaria	2.7	2.4	0.8	1.1	17.0	16.0
Phoma	-	0.1	0.8	-	17.7	13.5
Trichotecium	-	-	-	-	1.9	10.2
Cryptococcus	-	-	-	-	0.2	10.2
Cephalosporium	1.3	-	0.8	-	11.0	0.6

[1]Source: Aracaju (present study), Fortaleza (Menezes *et al.*, 2006), Natal (Oliveira *et al.*, 1993); Porto Alegre (Homrich, M.H. 1961), São Paulo (Gambale *et al.*, 1983), Presidente Prudente (Buck & Gambale, 1985).