

Viable airborne fungi in Riyadh, Saudi Arabia

Abdulrahman Sulaiman Al-Suwaine¹, Syed Mohammed Hasnain¹ and Ali Hassan Bahkali^{2*}

¹Department of Biological and Medical Research, King Faisal Specialist Hospital and Research Center, P.O. Box 3354, Riyadh 11211, Saudi Arabia; ²Department of Botany and Microbiology, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia

(*author for correspondence, e-mail: hasnain@kfshrc.edu.sa; fax: 966 1 4674253)

Received 9 April 1998; accepted in final form 19 November 1998

Key words: aerobiological study, allergenic fungi, seasonal fluctuation, Riyadh city

Abstract

An aerobiological study to identify and quantify allergenic fungi and their seasonal fluctuations was conducted at two different sites, (Al-Batha, a more developed area in the south and Al-Ulia, a less developed area in the north) in Riyadh city, using portable Personal Volumetric Air Sampler (Burkard Manufacturing Co., England). Sampling was conducted twice a week in both the morning and in the afternoon at both sites, for a period of 12 months. Airborne fungi were grouped into “major” and “minor” components depending upon their frequency of appearance and catch percentage in the air. *Cladosporium spp.*, *Penicillium spp.*, *Aspergillus spp.*, *Alternaria spp.* and *Ulocladium spp.* were included as major components. Minor components included *Drechslera spp.*, *Rhizopus spp.*, *Fusarium spp.* and *Stachybotrys spp.* In general, higher concentrations of fungi were found at the developed (Al-Batha) site than at the less developed (Al-Ulia) site, both in the morning and in the afternoon.

1. Introduction

Aerobiology is a scientific discipline focused on the transport of airborne organisms in both outdoor and indoor environments (Al-Doory and Domson, 1984; Cosentio et al., 1990). Thus, aerobiology concerns the origin, release, transport and surface impact of wind-borne biological particles in the troposphere (Middleton et al., 1983). These biological particles include bacteria, fungal spores (mould spores), algae, viruses, protozoa, pollen grains etc. Amongst these, fungal spores comprise the greatest portion of suspended biological material in the air (Salvaggio and Aukrust, 1981). The source of fungal spores and hyphal fragments is often unknown (Gregory, 1973), unlike that of pollen grains, which are easily traced back to their plant species.

Airborne fungal spores are ubiquitous in nature (Burge, 1985; Solomon, 1978). The concentration of airborne spores of fungi varies according to location, altitude, time of the day, season of the year, condition of the surrounding areas (e.g. parks, gardens, etc.)

and climatic conditions (e.g. temperature, humidity) (Al-Doory and Domson, 1984).

The last survey on airborne fungal allergens in Riyadh was conducted using Burkard Volumetric Spore Trap, and gravity-settle plate techniques (Al-Frayh et al., 1988; Hasnain et al., 1989). The above communications report results which revealed the presence of various types of fungal spores in the environment of Saudi Arabia. The aim of the present study was to compare a developed site with a less developed one, and the morning concentration with evening concentration of airborne fungal spores in Riyadh, using a Portable Air Sampler for Agar Plates, a viable volumetric method, (Burkard Manufacturing Co, Ltd, UK).

2. Materials and methods

2.1 Site description

Riyadh is 1600 square kilometre in area with approximately 2 million population. There is little rainfall in

Table 1. Percentage of various airborne components of the two sites in Riyadh.

Genera	Total CFU (Al-Batha)	Total CFU (Al-Ulia)	% colonies (Al-Batha)	% colonies (Al-Ulia)
<i>Cladosporium</i>	5964	5485	38.4	43.2
<i>Penicillium</i>	3587	1845	23.1	14.5
<i>Aspergillus</i>	2908	2182	18.7	17.2
<i>Alternaria</i>	805	785	5.2	6.2
<i>Ulocladium</i>	692	763	4.5	6.0
<i>Drechslera</i>	238	265	1.5	2.1
<i>Rhizopus</i>	72	43	0.5	0.3
<i>Stachybotrys</i>	68	39	0.4	0.3
<i>Fusarium</i>	45	43	0.3	0.3
Unknown	1151	1248	7.4	9.8
Total	15530	12698	100.00	100.00

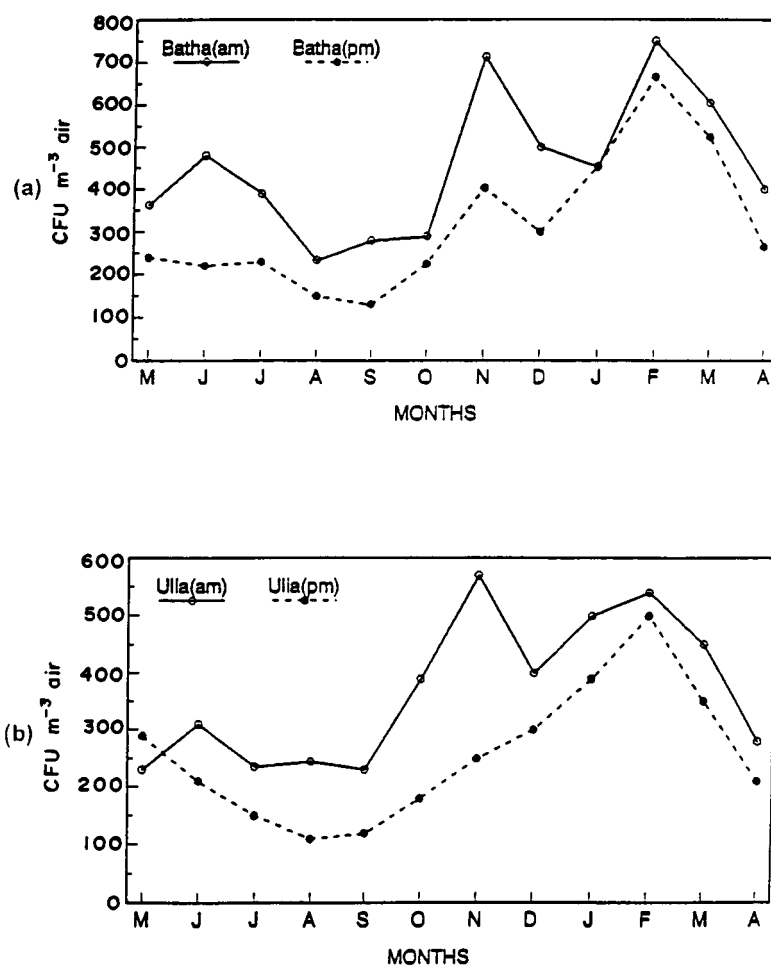


Figure 1. Mean monthly variation of total airborne fungi at Al-Batha(a) and Al-Ulia (b) sites both morning and afternoon concentration.

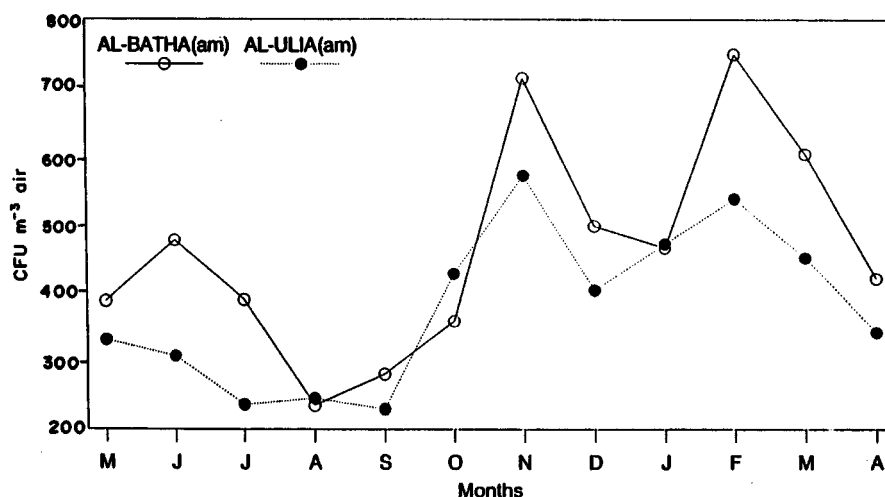


Figure 2. The mean monthly variation of the total airborne fungi at both sites for morning concentration.

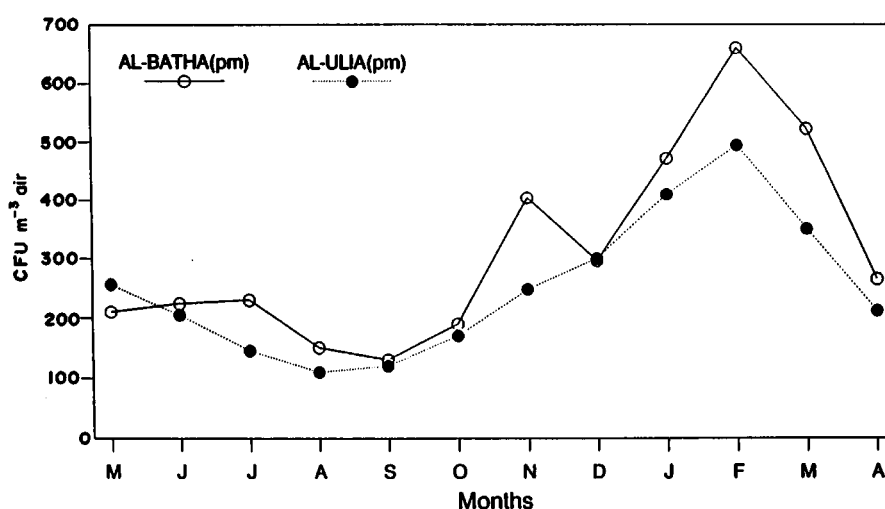


Figure 3. The mean monthly variation of the total airborne fungi at both sites for afternoon concentration.

the city. The city is 606 metre above the sea level. Two sites were chosen for sampling airborne fungi in Riyadh city. They were Al-Batha and Al-Ulia. The distance between the two sites is 7 kilometres. Al-Batha is a developed area (thickly populated, higher concentration of buildings, etc.), located in the south of Riyadh. It mainly consists of old commercial buildings, known as the heart of the city. Roads and streets are narrow, crowded and populated. There are a number of traditional mud homes in the area. Al-Ulia is located in the north of Riyadh, a modern, new, and less populated area. It has a very modernized shopping centre and villas with open planned streets which are planted and irrigated regularly.

The weather in Riyadh is rather hot and dry. The temperature in summer normally ranges between 35 °C and 45 °C during the day time. In winter, days are moderate with cool nights.

2.2 Sampling method

Twice a week sampling using two Portable Air Sampler for Agar Plates (Burkard Manufacturing Co. Ltd. England) was carried out at both sites (viz. Al-Batha and Al-Ulia), over a period of 12 months during 1990–91. Sampling was conducted at two different times. Morning samplings between 9–10 a.m. and afternoon samplings between 3–4 p.m. One hour interval was allowed to reach the sampling site by

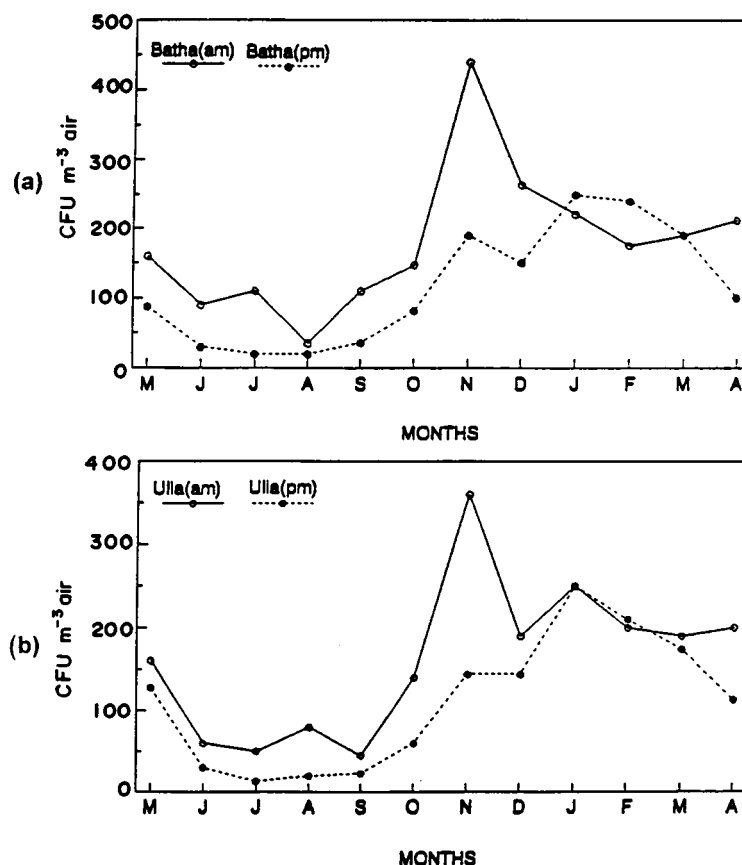


Figure 4. Mean monthly variation of *Cladosporium* spp. At Al-Batha(a) and Al-Ulia(b) sites both morning and afternoon concentration.

road both in the morning and afternoon. The choice of two different times was aimed at providing the diurnal patterns of fungi in the two locations as well as variation between the location (Al-Suwaine, 1992).

The air suction rate of the volumetric air sampler was maintained at 10 l/min. Both air samplers were used at a time with two different media. Sampling exposure was for 10 minutes duration. The two samplers were operated about 20 cm above the ground.

It was experienced that some airborne fungi grow faster than others in one specific media. To avoid overcrowding and to count the number of colonies, two different culture media were used for each sampling, viz. Sabouraud's dextrose agar (Oxoid) and Czapek Dox agar (Oxoid). In each of the culture media 1% streptomycin antibiotic was added in order to inhibit the growth of bacteria. All the plates of the two different media were incubated at room temperature. The incubation time was different for the two media, five days for Sabouraud dextrose agar and 7 days for Czapek Dox agar. A mean number of colonies of the

two media was calculated as colony forming units (CFU) for each locations.

Preliminary identification and counting of similar colonies were carried out after 5–7 days incubation and again when all the propagules had developed. Sample colonies were isolated in pure culture for identification according to Ellis (1971). These identifications were reconfirmed by the Commonwealth Mycological Institute (CMI, Surrey, England).

3. Results

The genera identified from the two different sites using two different culture media and at two different times for the whole year are presented. Depending upon their frequency of appearance and the number in the air sample, genera were grouped as "major components" and "minor components". Major components included most frequently encountered genera such as *Cladosporium* while minor components included less

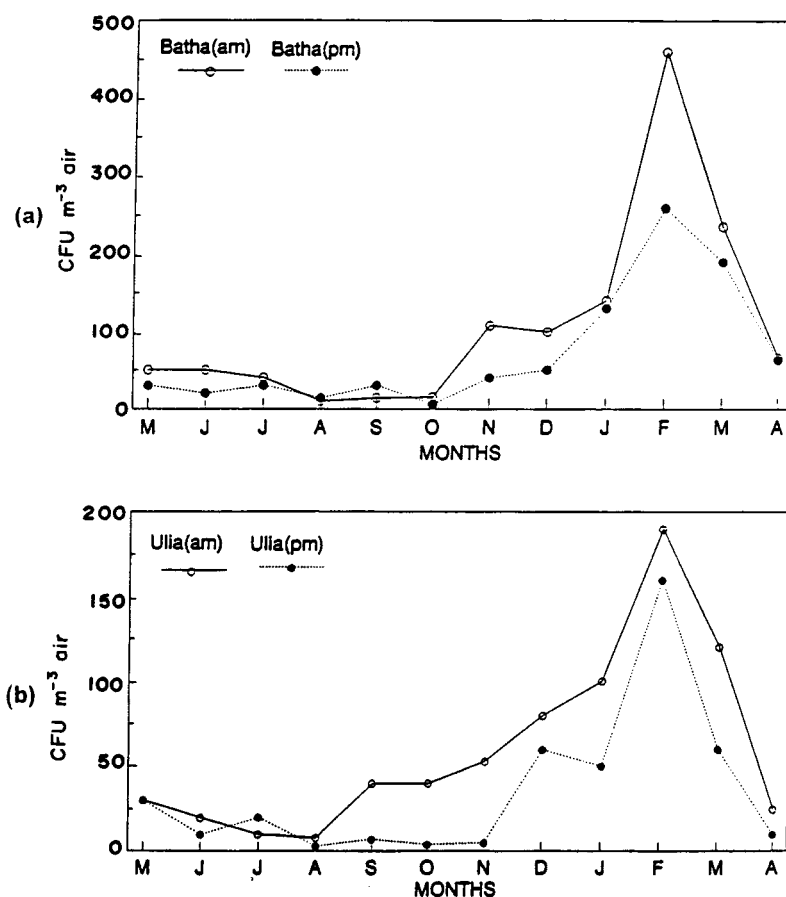


Figure 5. Mean monthly variation of *Penicillium* spp. At Al-Batha(a) and Al-Ulia(b) sites both morning and afternoon concentration.

frequent and sporadic types. The percentage of various components in the air are presented in Table 1. The mean total (number) colonies forming units (CFU) of *Cladosporium* spp. colonies isolated was 5964 which constituted 38.4% of the total airborne fungi at Al-Batha, while a total of 5485 colonies were recorded at Al-Ulia, which constituted 43.2% of the total airborne fungi. The total number of colonies of *Penicillium* spp. was 3587 which constituted 23% of the total airborne fungi at Al-Batha, and the mean total colony of *Penicillium* spp. colonies at Al-Ulia was 1845 which constituted 14.5% of the total airborne fungi. The mean total colony of *Aspergillus* spp. was 2908 which constituted 18.7% at Al-Batha, while the mean total number of *Aspergillus* spp. colonies at Al-Ulia was 2182 which constituted 17.2%. The mean total number of *Alternaria* spp. colonies was 805 (5.2%) at Al-Batha, while the total number of colonies of *Alternaria* spp. was 785 which (6.2%) at Al-Ulia. The total number of *Ulocladium* spp. colonies was 692

which constituted 4.5% at Al-Batha, while the total number of *Ulocladium* spp. at Al-Ulia was 763 which constituted 6%. The table also shows the percentages of various airborne components.

Mean monthly variation of total airborne CFU is presented in Figure 1(a&b). The figure shows that the total spores were present in the air throughout the year both in the morning and in the afternoon at Al-Batha site. However, from June 10 to October, the mean concentration was <500 CFU per cubic metre of air in the morning, while during the same period the mean concentration was <250 CFU per cubic metre of air in the afternoon. Concentrations rose from October onward with a peak for the morning concentrations of 750 CFU per cubic metre of air in November, followed by another peak in February of the next year, and for the afternoon concentrations the peak of 650 CFU per cubic metre of air was in February. With the increase of temperature during March and April the mean concentration tended to decline.

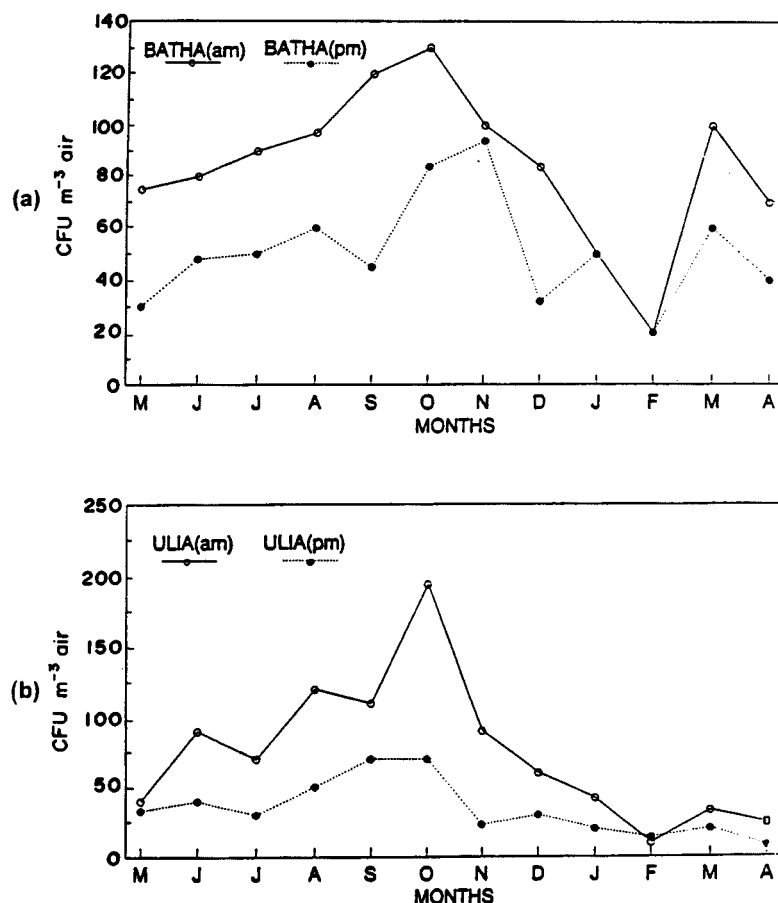


Figure 6. Mean monthly variation of *Aspergillus* spp. at Al-Batha(a) and Al-Ulia(b) sites both morning and afternoon concentration.

Concentrations remain high during October to March at both sites. There appears to be some decline during very cold months, i.e. December. However, with the further increase in temperature, the concentrations at both sites display another peak which approaches 800 at Al-Batha and 600 per cubic metre of air at Al-Ulia.

The mean monthly variation of total airborne fungal spores at Al-Ulia is presented in Figure 1(b). The figure shows that the fungal spores were present in the air throughout the year both in the morning and in the afternoon at this site.

However, from June to September the mean concentration were <300 CFU per cubic metre of air in the morning, while during the same period concentrations were <200 per cubic metre of air in the afternoon. Concentrations rose both in the morning and in the afternoon at the Al-Ulia site from September onward with a peak of 560 CFU per cubic metre of air occurring for morning concentrations in

November, and for afternoon concentrations a peak of 500 CFU per cubic metre in February. With increase in the temperature, the mean concentration tend to decline.

The mean monthly variation of total airborne fungi in the morning and in the afternoon at the two sites is presented in Figure 2. The figure shows that morning concentrations at Al-Batha were higher than morning concentrations at Al-Ulia, with two peaks (700, 750 mean concentration) in November and February for morning at both sites. Figure 3 shows that afternoon concentrations at Al-Batha were higher than afternoon concentrations at the Al-Ulia site. There were two peaks of mean concentration, of 450 and 650 CFU per cubic metre of air in November and February respectively for the afternoon at Al-Batha, and one peak of 500 CFU in February in the afternoon at the Al-Ulia site.

Mean monthly variations of *Cladosporium* spp., *Penicillium* spp., *Aspergillus* spp., *Alternaria* spp.

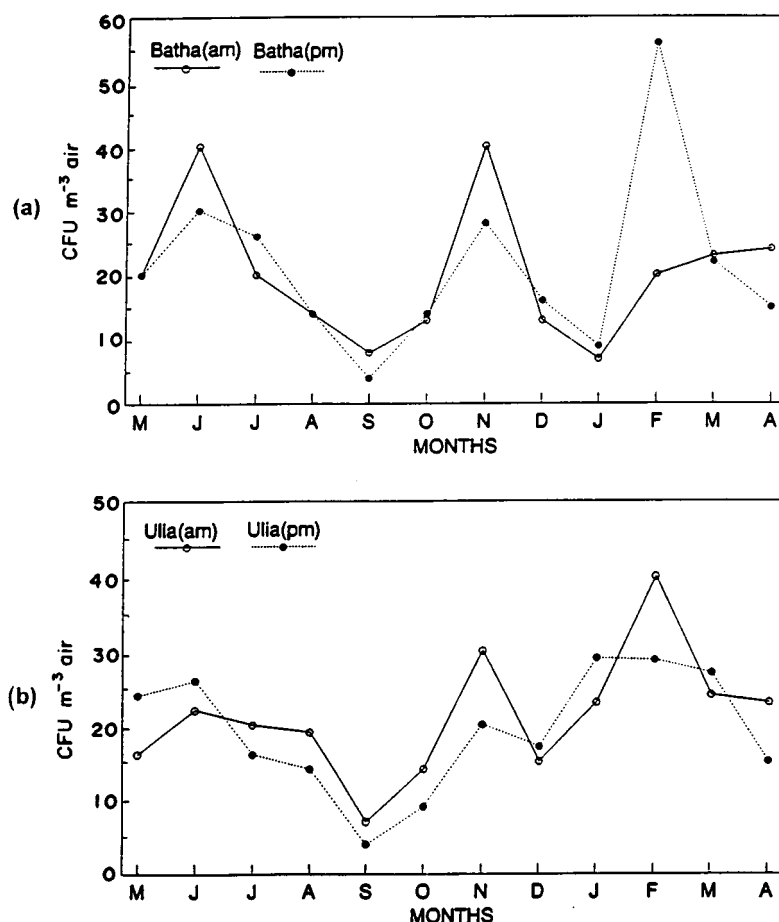


Figure 7. Mean monthly variation of *Alternaria* spp. at Al-Batha(a) and Al-Ulia(b) sites both morning and afternoon concentration.

and *Ulocladium* spp. are presented in Figures 4–8. There were increases in concentrations both in the morning and in the afternoon. With increase in temperature the concentration tended to decline. Both sites display almost a similar pattern of rise and fall in concentration. The morning concentration was always higher than the afternoon concentration. Distribution of *Cladosporium* is ubiquitous and the two sites have the higher level present during the same period. Monthly variation of *Alternaria* spp. at both sites (Figure 7) display no clear seasonal pattern at either site, but November and late winter show comparatively higher concentration for both morning and afternoon.

The monthly total concentrations of minor components (*Drechslera* spp., *Rhizopus* spp., *Stachybotrys* spp. and *Fusarium* spp.) are presented in Figure 9(a&b) for Al-Batha and Al-Ulia site.

4. Discussion

The study revealed that the airborne fungi are present throughout the year in the Riyadh atmosphere. The study showed that the most prevalent (major components) fungal spores in the air of Riyadh were *Cladosporium* spp., *Penicillium* spp., *Aspergillus* spp., *Alternaria* spp. and *Ulocladium* spp. A number of other spores with casual or sporadic appearances were *Drechslera* spp., *Rhizopus* spp., *Stachybotrys* spp. and *Fusarium* spp., termed as minor components. These results are comparable to those from a previous study in Riyadh (Hasnain et al., 1989) and other studies in Ahwaz, Iran (Hariri et al., 1978), Cairo, Egypt (Youssef and El-Din, 1988) and Kuwait city, Kuwait (Moustafa and Kamel, 1976) as well. Studies in South and Central America (Noranjo, 1958) have shown that *Penicillium* *Aspergillus* and *Alternaria* are prevalent airborne fungi.

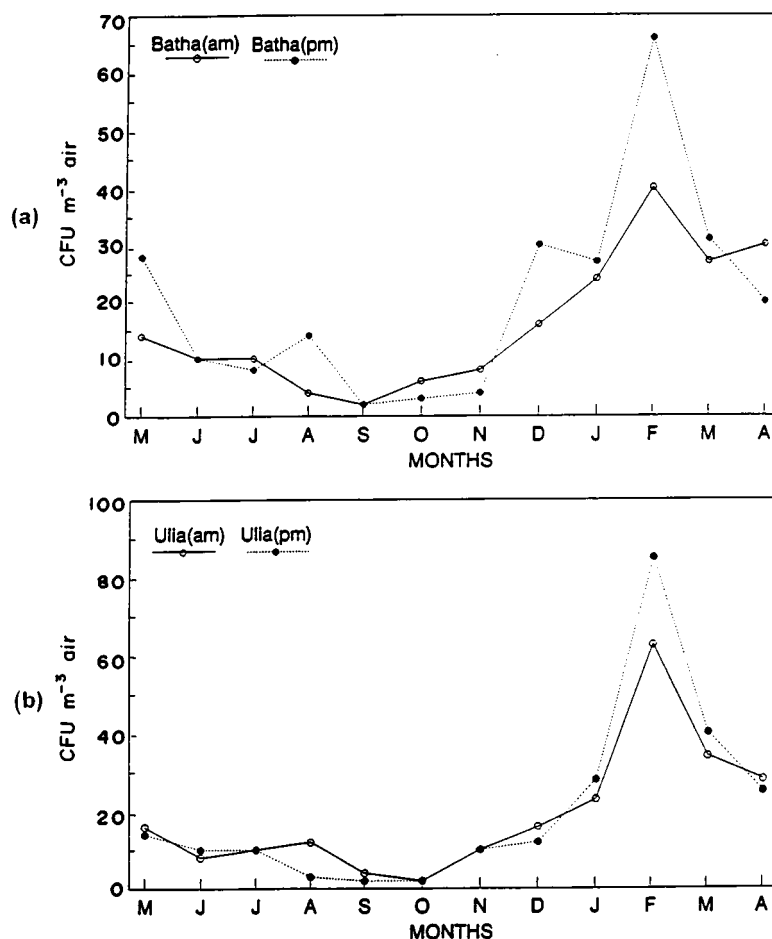


Figure 8. Mean monthly variation of *Ulocladium* spp. at Al-Batha(a) and Al-Ulia(b) sites both morning and afternoon concentration.

The seasonal variation of the total airborne fungi and for major generic categories (*Cladosporium*, *Penicillium* and *Ulocladium*) appear to show a higher concentration in the cold months (winter) and a low concentration in (summer) hot months. The individual generic categories followed the same pattern as the total airborne count in their order of distribution, seasonal fluctuation and monthly variation.

Cladosporium spp. were most prevalent at both sites and appeared to be the most common genus in almost all the zones studied (Turner, 1966). The abundance of this fungus has been revealed in both volumetric and culture plate studies. In our study, *Cladosporium* spp. comprised 38.4% of the total airborne fungi at Al-Batha and 43.4% at Al-Ulia. *Penicillium* spp. and *Aspergillus* spp. spores are widespread in air and provide a larger proportion of catch by culturing than by other methods (Lumpkins, 1976). *Penicillium* spp. were found in higher concentration

(23%) at Al-Batha than (14%) at Al-Ulia. *Aspergillus* spp. gave almost the same percentage 18.7% at Al-Batha and 17.2% at Al-Ulia. *Alternaria* spp. 5.2% at Al-Batha and 6.2 at Al-Ulia. *Ulocladium* spp. 5% of the total at Al-Batha and 6% of the total at Al-Ulia.

Cladosporium spp. showed a seasonal variation with concentrations of airborne spores high in winter and low in summer. *Penicillium* spp. increase in winter and early spring which was comparable to the study at Ahwaz, Iran (Hariri et al., 1978).

The results show a possible link between the temperature and the concentration of airborne fungal spores which exhibit a tendency of rise and peak in cooler months, except *Aspergillus*, which showed higher concentrations in autumn and summer.

Concentrations of fungal spores at both sites and at both sampling times showed seasonal variation, with the concentrations of fungal spores higher at Al-Batha. The present study showed similarities in

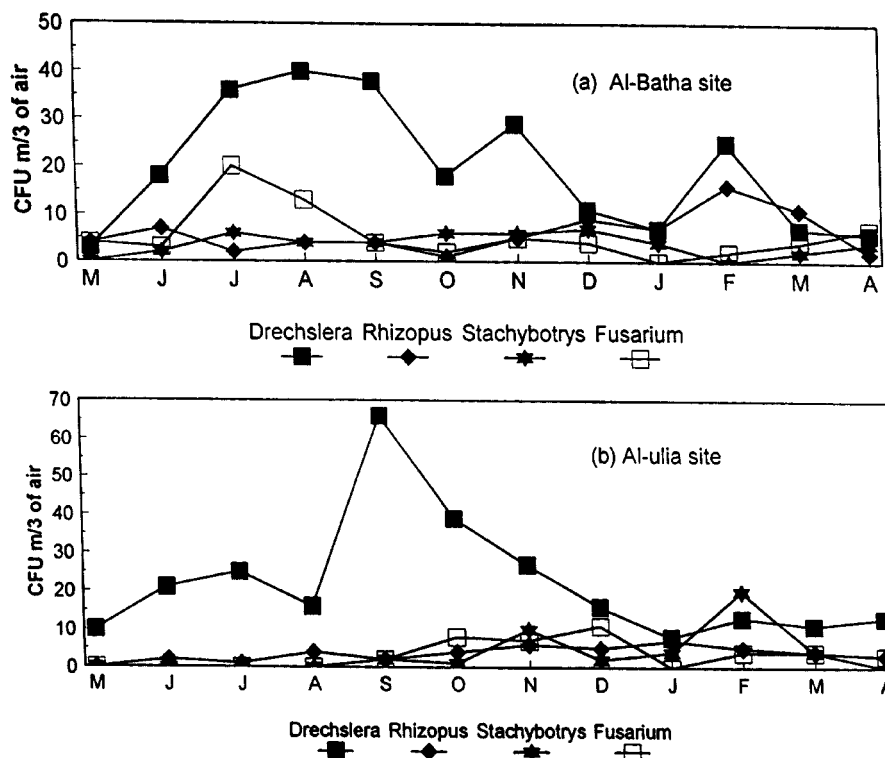


Figure 9. Seasonal periodicities of minor fungal components at the two sites.

both quantitative and qualitative compositions to many comparable investigations in subtropical areas such as Baghdad (Iraq), as reported by Al-Tikriti et al. (1980). Ahwaz (Iran), Cairo (Egypt) and Kuwait, as well as other studies in Saudi Arabia (Al-Frayh et al., 1988; Hasnain et al., 1989).

Acknowledgment

The paper is part of an MSc thesis conducted by the first author and was supported by King Saud University and King Faisal Specialist Hospital and Research Centre, Riyadh, Saudi Arabia.

References

- Al-Doory Y., Domson J.F., Howard W.A. and Sly R.M.: 1980, Airborne fungi and pollen of the Washington, D.C., Metropolitan area. *Annals of Allergy* **45**, 360–367.
- Al-Doory Y.: 1984, chapter 3. In: Y. Al-Doory and J.F. Domson (eds), *Mould Allergy*. Lea & Febiger, Philadelphia, 287 pp.
- Al-Frayh A., Hasnain S.M., Wilson J.D. and Al-Harfi H.A.: 1988, Fungal allergens in the atmosphere of Riyadh, a preliminary communication. *Annals of Saudi Medicine* **8**(4), 248–251.
- Al-Suwaine A.S.: 1992, A study of airborne viable fungi in Riyadh and their possible role as Aero-Allergens. M.Sc. Thesis, King Saud University, Riyadh. 104 pp.
- Al-Tikriti S., Al-Salihi M. and Gaillard G.E.: 1980, Pollen and mold survey of Bagdad, Iraq. *Annals of Allergy* **45**, 97–99.
- Burge H.A.: 1985, Fungus allergens. *Clin. Rev. Allergy* **3**, 319–329.
- Cosentio S., Pisano P.L., Fadda M.E. and Palmas F.: 1990, Pollen and mold allergy: Aerobiologic survey in the atmosphere of Cagliari, Italy (1986–1988). *Annals of Allergy* **65**, 393–400.
- Ellis M.B.: 1971, *Dematiaceous Hyphomycetes*. Commonwealth Mycological Institute, Kew, 608 pp.
- Gregory, P.H.: 1973, *The Microbiology of the Atmosphere*. Leonard Hill, England, 377 p.
- Hariri A.R., Ghahary M.S., Naderinasab M. and Kimberlin C.: 1978, Airborne fungal spores in Ahwaz, Iran. *Annals of Allergy* **40**, 349–352.
- Hasnain S.M., Al-Frayh A., Thorogood R. and Harfi H.: 1989, Seasonal periodicities of fungal allergens in the atmosphere of Riyadh. *Annals of Saudi Medicine* **9**(4), 337–343.
- Lumpkins E.D., Corbit S.L. and Tiedeman G.M.: 1973, Airborne fungi survey I. Culture-plate survey of the home environment. *Annals of Allergy* **31**, 361–370.
- Middleton E., Reed C.E. and Ellis E.F.: 1983, *Allergy. Principles and Practice*. C.V. Mosby, St. Louis/Toronto, pp. 295–302.
- Moustafa A.F. and Kamel Susan M.: 1976, A study of fungal spores population in the atmosphere of Kuwait. *Mycopathologia* **59**, 29–35.
- Noranjo, P.: 1958, Etiological aspects of respiratory allergy in tropical countries of Central and South America. *J. Allergy* **29**, 362.

- Salvaggio J. and Lars A.: 1981, Mold-induced asthma. *The Journal of Allergy and Clinical Immunology* **68**, 327–364.
- Solomon W.R. and Mathews K.P.: 1978, Aerobiology and inhalant allergens. In: E. Middleton Jr, C.E. Reed and E.F. Ellis (eds), *Allergy Principles and Practice*. St. Louis, The C.V. Mosby Co., 899 pp.
- Turner P.D.: 1966, The fungal air spora of HongKong as determined by the agar plate method. *Trans. Br. Mycol Soc.* **49**, 255–267.
- Youssef A.Y. and El-Din A.K.: 1988, Airborne spores of opportunistic fungi in the atmosphere of Cairo, Egypt. *Grana* **27**, 89–92.