

A STUDY OF FUNGAL SPORE POPULATIONS IN THE ATMOSPHERE OF KUWAIT

A. F. MOUSTAFA & Susan M. KAMEL

Department of Botany, University of Kuwait, Kuwait

Abstract

The fungal air-spores of Kuwait was investigated using the Petri-dish trapping technique. During the period from 1st April, 1974 to 30th June, 1975, a total of 3685 colonies were recorded from 2 % malt agar plates. Fifty-five genera and 116 species were identified. *Alternaria* occupied the first place in the order of percentage incidence, being represented by 18.3 % of the entire catch, followed by *Aspergillus* (17.1 %), *Penicillium* (14 %), *Cladosporium* (13.6 %), *Drechslera* (13.3 %), and *Ulocladium* (7.1 %). The widest spectrum of species was displayed by *Aspergillus* (possessed 19 species) followed by *Penicillium* (17 species), *Alternaria* (6 species), *Drechslera* (5 species), and *Ulocladium* (4 species). The monthly total number of fungi showed marked seasonal periodicity with the greatest number of colonies occurring in March-April and November. The lowest counts were recorded in mid-summer (July) and mid-winter (January). Only 220 colonies and 17 species of thermophilous fungi were reported from plates incubated at 45 °C. The most common species were *Aspergillus fumigatus* and *A. terreus*.

Introduction

The study of fungal air-spores is of great importance and interest in order to understand the dissemination, spread, and movement of the microbes, particularly the pathogenic ones, in the atmosphere. Since Kuwait is not an agricultural country, this study may help in finding out suitable means to control the various types of human diseases induced by fungal spores as they are well recognized as etiologic agents of several mycotic diseases, also asthma and allergies (5, 21, 22).

The air fungal spores has been studied in several parts of the world including tropical, subtropical, and temperate zones. However, data from the Middle East area is very

limited; in Egypt, Saad (24), Zaky (29) and Moustafa (16); in Israel, Ben-Meir (4), Barkai-Golan (1, 2), Barkai-Golan & Glazer (3). In Kuwait, very little is known about the quantitative and qualitative composition of the atmospheric fungal population. The limited information obtained from a previous trial (9), calls for an extensive study of fungal air-spores in the atmosphere of Kuwait.

The present study was designed mainly to survey and compare the fungal air-spores of Kuwait with that carried out in other parts of the world, especially those in subtropical regions, and to show the seasonal periodicity in the fungal population and its relation to changes in climatic conditions.

Materials and methods

The state of Kuwait occupies the northeastern part of the Arabian Peninsula and characterized by two distinct seasons, very hot, dry summers and cool to mild rainy winters (14). The country is composed of arid deserts with very sparse, wild vegetation and no agricultural plant cover. Summer months from May to September, inclusive, are practically dry, since no rain falls and the relative humidity is very low (ranging between 20 % and 30 %). The temperature during this season is always very high (exceeds 35 °C) and maxima of 48 °C and 50 °C are frequently reported in June and July every year.

In winter months, from mid-November to the end of February, the rain fall and relative humidity are generally high with their maxima 24.2 mm & 85 % reported in January. The mean temperature ranges between 16 °C and 24 °C and its minimum is reached usually in January.

The wind blows from two main directions, the northwest and, to a lesser extent, the southeast. It frequently raises dust and sand, particularly in June and July, causing very strong sandstorms, locally known as 'Toaz'.

Spore-trapping by deposition using the exposed plate method was adopted. Sampling was made on the roof of the

Faculty of Science at Khalidiah, which is about 20 feet high. Preliminary tests showed that the best time for sampling was between 12-2 P.M. and an exposure time of 10 minutes proved to be very suitable as it gave adequate colony counts. Malt extract agar was found to be the best medium. Two petri-dishes (9 cm diameter each) of 2% malt agar were exposed daily from the beginning of April 1974 to the end of June 1975. Exposures were made daily except Fridays, holidays, and days of adverse weather (rainy or dusty). After sampling, one of the plates was incubated at 25°C and the other at 45°C to investigate the thermophilous species in the air. In order to reduce the rapid and excessive desiccation of the agar, open containers filled with distilled water were kept inside the incubator chamber to keep the relative humidity between 70 % and 75 %.

Counts and identifications were made after 10 days incubation. Colonies of slow-growing fungi, and those which failed to sporulate on the original medium, were transferred to other media viz. Czapek's+yeast extract (0.5 %), potato dextrose or oat-meal agars. When sporulation of some forms was not induced on these media, they were classified as sterile forms.

The climatological data was kindly supplied by the Weather Record Department at Kuwait Airport.

Results

Counts and nature of fungi isolated

A total of 3685 colonies were recorded during the 360 days on which exposures were made, in the period from the beginning of April 1974 to the end of June 1975. It was possible to identify 55 genera and 116 species. Their total counts, percentage incidence and frequency of occurrence (expressed as number of isolations out of 15) are given in Table 1.

The most common fungus isolated from the air was *Alternaria*, represented by 18.3 % of all colonies. *Aspergillus* was the second in order of incidence, constituting 17.1 %, followed by *Penicillium* (14.0 %), *Cladosporium* (13.6 %), *Drechslera* (13.3 %), *Ulocladium* (7.1 %), *Phoma* (4.3 %), *Aureobasidium* (3.4 %), *Fusarium* (1.4 %), and *Paecilomyces* (1.0 %). The remaining genera were of infrequent occurrence and contributed less than 1.0 % of the total catch.

Most of the fungi recorded were members of the Hyphomycetes (88 species), the remainder were as follows: Zygomycetes 8, Ascomycetes 11, and 9 Coelomycetes. The widest spectrum of species (Table 2), was displayed by the

Table 1. Total counts, percentage incidence, and frequency of occurrence of the fungal genera recorded.
(Frequencies are expressed as number of isolations out of 15)

Genus	total count	% incidence	isolations out of 15*	occurrence
<i>Alternaria</i>	(6) 672	18.3	15	H
<i>Aspergillus</i>	(19) 630	17.1	15	H
<i>Penicillium</i>	(17) 518	14.0	15	H
<i>Cladosporium</i>	(2) 500	13.6	15	H
<i>Drechslera</i>	(5) 489	13.3	15	H
<i>Ulocladium</i>	(4) 261	7.1	15	H
<i>Phoma</i>	(4) 158	4.3	14	H
<i>Aureobasidium</i>	(1) 127	3.4	13	H
<i>Fusarium</i>	(2) 50	1.4	9	M
<i>Paecilomyces</i>	(3) 38	1.0	9	M
<i>Cephalosporium</i>	(1) 27	0.7	6	M
<i>Rhizopus</i>	(2) 21	0.6	7	M
<i>Myrothecium</i>	(2) 20	0.5	7	M
<i>Embellisia</i>	(1) 16	0.4	9	M
<i>Stemphylium</i>	(1) 14	0.4	7	M
<i>Microdiplozia</i>	(1) 10	0.3	6	M
<i>Pyrenochaeta</i>	(1) 9	0.2	7	M
<i>Hendersonia</i>	(1) 8	0.2	5	M
<i>Contothyrus</i>	(1) 8	0.2	4	M
<i>Sphaeronaema</i>	(1) 7	0.2	5	M
<i>Scolecobasidium</i>	(2) 7	0.2	6	M
<i>Pithomyces</i>	(2) 7	0.2	6	M
<i>Tritirachium</i>	(1) 6	0.2	4	M
<i>Periconia</i>	(2) 6	0.2	6	M
<i>Camarosporium</i>	(1) 5	0.1	4	M
<i>Botrytis</i>	(1) 5	0.1	5	M
<i>Epicoecum</i>	(1) 5	0.1	4	M
<i>Abidia</i>	(1) 6	0.2	3	L
<i>Stachybotrys</i>	(1) 6	0.2	3	L
<i>Mucor</i>	(1) 4	0.1	3	L
<i>Scopulariopsis</i>	(2) 4	0.1	3	L
<i>Chaetomium</i>	(1) 3	0.1	3	L
<i>Neurospora</i>	(1) 3	0.1	3	L
<i>Nigrospora</i>	(1) 3	0.1	3	L
<i>Cunninghamella</i>	(1) 3	0.1	3	L
<i>Pleospora</i>	(1) 2	0.1	2	L
<i>Trichothecium</i>	(1) 2	0.1	2	L
<i>Arthrinium</i>	(1) 2	0.1	2	L
<i>Chrysosporium</i>	(1) 2	0.1	2	L
<i>Bartallinia</i>	(1) 2	0.1	2	L
<i>Pyrenophora</i>	(1) 2	0.1	2	L
<i>Hyalocladium</i>	(1) 2	0.1	1	L
<i>Phialophora</i>	(1) 2	0.1	1	L
<i>Tilletiopsis</i>	(1) 2	0.1	1	L
<i>Trichoderma</i>	(1) 2	0.1	1	L
<i>Cephalophora</i>	(1) 1	0.1	1	L
<i>Circinella</i>	(1) 1	0.1	1	L
<i>Choanephora</i>	(1) 1	0.1	1	L
<i>Humicola</i>	(1) 1	0.1	1	L
<i>Trichurus</i>	(1) 1	0.1	1	L
<i>Graphium</i>	(1) 1	0.1	1	L
<i>Sporotrichum</i>	(1) 1	0.1	1	L
<i>Sepedonium</i>	(1) 1	0.1	1	L
<i>Thielavia</i>	(1) 1	0.1	1	L
<i>Syncephalastrum</i>	(1) 1	0.1	1	L

Total count : 3685

* 15 is the number of sampling months

- Figures between parentheses refer to the number of species

Occurrence H = High occurrence; recorded 10-15 times

M = Moderate occurrence; 4-9 times

L = Low occurrence; less than 4 times

genus *Aspergillus*, being represented by 19 species. *Penicillium* came next in the range as it comprised 17 species, followed by *Alternaria* (6 spp.), *Ulocladium* (4 spp.), *Phoma*

Table 2. List of all species identified from air samples during the period April 1974 - June 1975. (Percentages are calculated to the genus count.)

Species	%	Species	%
<i>Alternaria alternata</i>	79.6	<i>P. minutella</i>	9.5
<i>A. chlamydospora</i>	14.4	<i>P. glomerata</i>	3.2
<i>A. tenuissima</i>	2.8	<i>Fusarium concolor</i>	82.5
<i>A. state of Pleospora infectoria</i>	1.2	<i>F. acuminatum</i>	17.5
<i>A. raphani</i>	1.2	<i>Paecilomyces terricola</i>	50.0
<i>A. phragmospora</i>	0.5	<i>P. variotii</i>	33.6
<i>Aspergillus flavus</i>	40.4	<i>P. roseolus</i>	16.4
<i>A. niger</i>	22.7	<i>Rhizopus arrhizus</i>	75.5
<i>A. fumigatus</i>	16.8	<i>R. stolonifer</i>	24.5
<i>A. terreus</i>	7.6	<i>Myrothecium verrucaria</i>	68.4
<i>A. sydowii</i>	2.1	<i>M. roridum</i>	31.6
<i>A. carneus</i>	1.6	<i>Pithomyces sacchari</i>	75.6
<i>A. ruber</i>	1.4	<i>P. atro-olivaceum</i>	24.4
<i>A. repens</i>	1.3	<i>Periconia atro-purpurea</i>	85.6
<i>A. amstelodami</i>	1.1	<i>P. digitata</i>	14.4
<i>A. parvaticus</i>	1.1	<i>Scopulariopsis candida</i>	66.5
<i>A. candidus</i>	1.0	<i>S. brevicaulis</i>	33.5
<i>A. tamarii</i>	0.8	<i>Cephalosporium</i> sp.	*
<i>A. nidulans</i>	0.6	<i>Embellisia chlamydospora</i>	*
<i>A. egyptiacus</i>	0.5	<i>Stemphylium botryosum</i>	*
<i>A. versicolor</i>	0.5	<i>Micodiplodia</i> sp.	*
<i>A. ustus</i>	0.3	<i>Pyrenochaeta acicola</i>	*
<i>A. rugulosus</i>	0.2	<i>Hendersonia</i> sp.	*
<i>A. fischeri</i> var <i>spinosus</i>	0.1	<i>Goniothyrium fockelii</i>	*
<i>A. ochraceus</i>	0.1	<i>Scolecobasidium variabile</i>	*
<i>Penicillium thomii</i>	39.9	<i>Aspidia</i> sp.	*
<i>P. varians</i>	12.7	<i>Stachybotrys atra</i>	*
<i>P. notatum</i>	8.9	<i>Camarosporium aequivocum</i>	*
<i>P. variable</i>	8.7	<i>Botrytis cinerea</i>	*
<i>P. islandicum</i>	7.7	<i>Epicoecum nigrum</i>	*
<i>P. chrysogenum</i>	4.9	<i>Mucor circinelloides</i>	*
<i>P. exallicum</i>	3.3	<i>Pleospora pentamera</i>	*
<i>P. cyclopium</i>	3.1	<i>Trichothecium roseum</i>	*
<i>P. roqueforti</i>	1.6	<i>Arthrinium phaeospermum</i>	*
<i>P. lilacinum</i>	1.4	<i>Cephalophora irregularis</i>	*
<i>P. corylophilum</i>	0.8	<i>Circinella umbellata</i>	*
<i>P. brevicompactum</i>	0.6	<i>Choanephora cucurbitarum</i>	*
<i>P. frequentans</i>	0.6	<i>Humicola grisea</i>	*
<i>P. spinulosum</i>	0.4	<i>Chrysosporium tropicum</i>	*
<i>P. raistrickii</i>	0.2	<i>Chaetomium reotophilum</i>	*
<i>P. crustosum</i>	0.2	<i>Trichurus spiralis</i>	*
<i>P. multicolor</i>	0.2	<i>Graphium</i> sp.	*
<i>Cladosporium cladosporoides</i>	77.6	<i>Sporotrichum thermophilum</i>	*
<i>C. herbarum</i>	22.4	<i>Neurospora tetrasperma</i>	*
<i>Drechslera hawaiiensis</i>	52.1	<i>Pialophora</i> sp.	*
<i>D. spicifera</i>	39.9	<i>Tilletiopsis lilacina</i>	*
<i>D. sp.</i>	2.5	<i>Sepedonium</i> sp.	*
<i>D. ellesii</i>	1.2	<i>Trichoderma</i> sp.	*
<i>D. rostrata</i>	1.8	<i>Nigrospora oryzae</i>	*
<i>Ulocladium botrytus</i>	44.8	<i>Thielavia microspora</i>	*
<i>U. atrum</i>	39.1	<i>Bartallinia robillardoides</i>	*
<i>U. chartarum</i>	12.6	<i>Sphaeronaema allahabadense</i>	*
<i>U. consortiale</i>	3.5	<i>Cunninghamella echinulata</i>	*
<i>Phoma fimeii</i>	67.7	<i>Syncephalastrum</i> sp.	*
<i>P. suadae</i>	15.2	<i>Pyrenophora</i> sp.	*

* Percentages are reported in Table 1.

(4 spp.), and *Paecilomyces* (3 spp.). The remaining genera were represented by mostly one species.

According to the frequency of occurrence (expressed as number of isolations out of 15), the fungi encountered could be classified into three main groups. Group 1, included high occurrence fungi (recorded 10 to 15 times out of 15). This group consisted of eight dominant genera, namely: *Alternaria*, *Aspergillus*, *Penicillium*, *Cladosporium*, *Drechslera*, *Ulocladium*, *Phoma* and *Aureobasidium*. The first six genera were consistently recorded throughout the exposure period, whilst the last two were missed in one and two months respectively. The members of this group collectively accounted for 91.5 % of the entire catch, whilst the other three groups only made 8.5 %. Group II, con-

tained moderate occurrence fungi which were recorded 4 to 9 times out of 15. It comprised 20 genera each of which accounted for less than 1 % of total colonies. In Group III, low occurrence fungi (isolated less than 4 times) are included. These fungi were irregularly or occasionally encountered. This last group is composed of 27 genera of which 14 were recorded only once, 5 twice and 9 three times.

Alternaria

The genus *Alternaria*, which occupied the first place of percentage incidence, was represented by six species (Table 2), of which *A. alternata* was the most common, as it made 79.5 % of the total genus catch, followed by *A. chlamydospora* (14.4 %), *A. tenuissima* (2.8 %), *A. state of Pleospora infectoria* (1.2 %), *A. raphani* (1.2 %), and *A. phragmospora* (0.5 %).

Aspergillus

Although the genus *Aspergillus* possessed the widest spectrum of species (19 spp.), it was found that only four were numerically dominant and very frequently isolated. These species were *A. flavus*, *A. niger*, *A. fumigatus*, and *A. terreus*. They collectively made 87.5 % of the genus count whilst the remaining 15 species constitute only 12.5 %.

Penicillium

Eighteen species of *Penicillium* were isolated of which only four species were highly frequent. These were: *P. thomii*, accounted for 39.9 % of the genus count, followed by *P. varians* (12.7 %), *P. notatum* (8.9 %), *P. variable* (8.7 %), and *P. islandicum* (7.7 %). The minor part of the remaining species were of moderate occurrence whilst the majority were rare.

Cladosporium

Only two species of *Cladosporium*, namely *C. cladosporoides* and *C. herbarum* were encountered, with the first species more abundant, contributing 77.6 % of the genus, whilst the latter only made 22.4 %.

Drechslera

This was represented by five species, two of which, namely: *D. hawaiiensis* and *D. spicifera*, were frequently isolated. They accounted for 52.1 % and 39.9 %, respectively, of the genus count. The other three species were less frequent.

Ulocladium

Four species of *Ulocladium* were encountered, but *U. botrytis* and *U. atrum* were by far the most common, and

made up 44.8 % and 39.1 %, respectively, of the genus catch, followed by *U. chartarum* (12.6 %) and *U. consortiale* (3.5 %).

Phoma

Phoma was represented by 4 species, two of which, namely: *P. fimeti* and *P. suaedee*, were reported many times and together constituted the major part of the genus (82.9 %) whilst *P. minutella* and *P. glomerata* were rarely recorded.

Seasonal periodicity

The seasonal change in the total number of colonies and the important meteorological records are summarized in Fig. 1. The monthly total counts of all fungi showed a seasonal fluctuation pattern of two peaks and two troughs. The first peak occurred in March–April and the second in October–November, whilst the two troughs occurred in January (mid-winter), and July (mid-summer).

The number of colonies decreased sharply twice a year in mid-summer, June–July when the highest temperature is always associated with the minimum relative humidity, and in mid-winter, January, when very low temperature is associated with maximum humidity. The monthly total count, increased again in late summer with the reduction of temperature and rise of relative humidity, to reach a

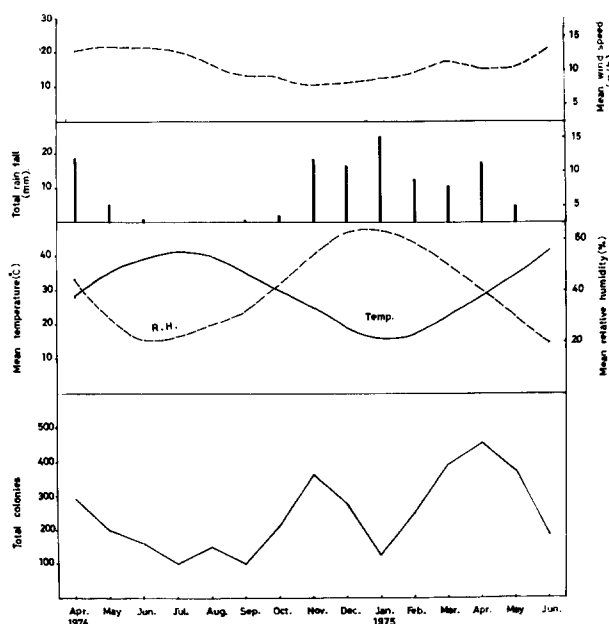


Fig. 1. Seasonal variation in total colonies in relation to changes in climatic conditions during the period April 1974–June 1975.

maximum count during autumn (October–November) and Spring (March–April), when moderate temperatures are usually associated with moderate relative humidity. Most of Group 1 fungi, (high occurrence species), showed marked seasonal periodicities with their highest counts consistently reported in the period March–April (Fig. 2).

Thermophilous fungi

Only 220 colonies and 17 thermophilous species were isolated during the whole period of sampling (Table 3). Some of those species were well known thermophiles whilst others were reported as thermophilous species from the air for the first time, such as *Chaetomium rectopilum*, *C.*

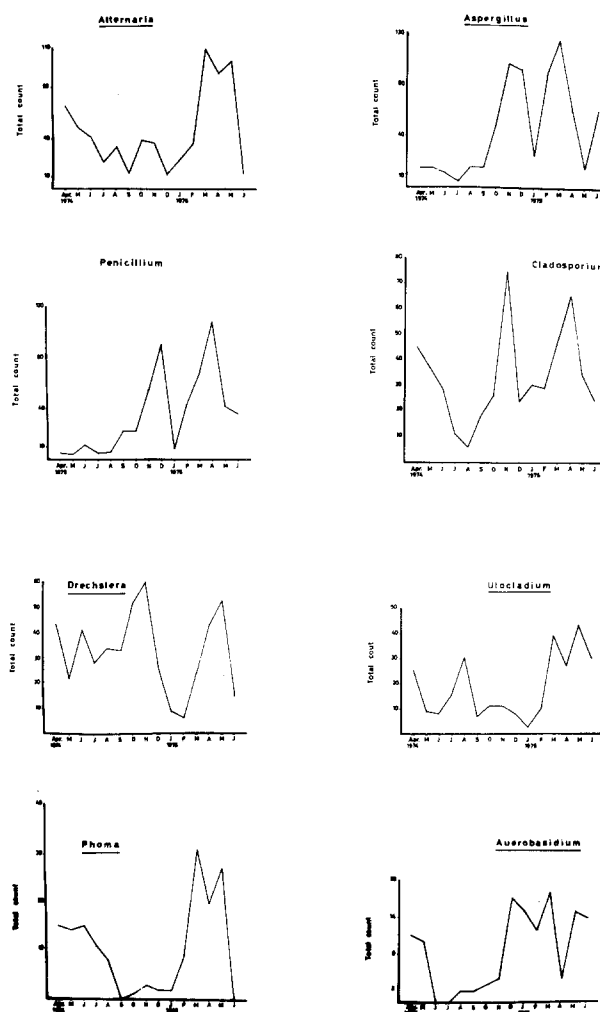


Fig. 2. Monthly variation in total isolates of dominant genera.

Table 3. Counts, percentage incidence, and frequency of thermophilous species isolated from the air.

Species	Total count	% incidence	isolations out of 15
<i>Aspergillus fumigatus</i>	80	36.4	12
<i>A. terreus</i>	22	10.0	9
<i>A. niger</i>	17	7.7	9
<i>A. nidulans</i>	15	6.8	8
<i>Chaetomium virginicum</i>	15	6.8	6
<i>Abidia</i> sp.	12	5.4	6
<i>Mucor</i> sp.	9	4.1	5
<i>Aspergillus carneus</i>	6	2.7	5
<i>A. flavipes</i>	6	2.7	5
<i>A. fisheri</i> var. <i>spinosus</i>	5	2.2	4
<i>Chaetomium rectopilum</i>	5	2.2	4
<i>Thielavia microspora</i>	4	1.8	4
<i>Paecilomyces variotii</i>	4	1.8	4
<i>Aspergillus candidus</i>	3	1.4	3
<i>Rhizopus arrhizus</i>	2	0.9	2
<i>A. amstelodami</i>	1	0.4	1
<i>Hemicola grisea</i>	1	0.4	1
Unknown sterile forms	13	6.0	-
Total count:	220	-	-

virginicum, *Thielavia microspora*, *Paecilomyces variotii*, *A. fisheri* var. *spinosus*, *Aspergillus carneus*, *A. flavipes*, *A. candidus*, and *A. amstelodami*.

As expected *A. fumigatus* was by far the most common, being encountered 12 times and totally counted 80, accounting for 36.4 % of the total catch. *A. terreus* and *A. niger* came next, both recorded 9 times and constituted 10 % and 7.7 % respectively of total thermophilous flora. The order of dominance (represented by frequency of occurrence), of the remaining species was more or less parallel to their percentage incidence and number of isolations.

The monthly total counts of the thermophilous fungi (Fig. 3), although extremely low, if compared with the

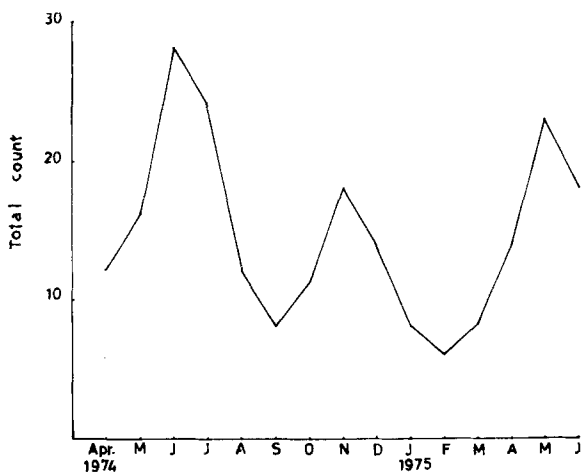


Fig. 3. Monthly changes in the total number of thermophilous colonies isolated from the air during the sampling period.

total counts of mesophiles, showed distinct seasonal variation of two peaks, one in winter (during the period October-December), and the other in summer (during the period May-July).

Discussion

Although the exposed plact method employed in this investigation had some limitations (13) it was of considerable help in getting reliable information on the number and nature of all viable spores and hyphal fragments, especially when the daily sample was taken under the same conditions (10). It has been extensively used in many studies on fungal air-spores carried out by many workers in different parts of the world, Saito (25), Cammack (6), Richards (23), Pawsey & Heath (20), Turner (26), Dransfield (10), Moustafa (16), Mishra (19), Upsher & Griffiths (27).

The air-spores of Kuwait showed numerous similarities in both qualitative and quantitative composition to many comparable investigations in subtropical areas such as those of Kansas, U.S.A. (15), Egypt (16), Northern Nigeria (10), Israel (1, 3, 4) and Hong Kong (26).

From the results, it was evident that most of the species of Group I fungi, which were highly frequent and numerically dominant in the air, are poorly represented in the desert soils of Kuwait (17, 18). On the contrary, members of Group II and III fungi, which although very common in the soil of Kuwait, form only a non-significant fraction of the fungal air-spores. This observation may give further support to the view that soil does not make any direct substantial contribution to the fungal spore content of the atmosphere (13).

The species recorded during our present trial differed considerably from those obtained by Davies (9). The major differences were the order of dominance and the smaller number of genera and species isolated. These differences may be attributed to the mode of sampling and identification. The sampling technique used by Davies was the trapping of spores on greased slides by Hirst volumetric spore trap in which identifications of fungal genera and species depend upon only spore morphology, which is considered a misleading character especially in unicellular spore producing forms. However, the observation on the maximum spore concentration in November was also reported by Davies.

The monthly changes in spore counts could not be correlated with any particular environmental factor. The effects of rain-fall, relative humidity and wind velocity were

not clear when considered separately but the high temperature and wind direction appeared to have had a considerable influence on the seasonal variation. The first factor probably affects the spore viability while the latter affects the spore concentration.

Although the air-spores have been extensively surveyed, in several parts of the world, few investigations have been carried out on the thermophilous fungi in the air (11). In our present study only seventeen species were encountered, some of them have been recorded for the first time from the air. Those newly reported species were *Aspergillus carneus*, *A. flavipes*, *A. fisheri* var. *spinosus*, *A. candidus*, *A. amstelodami*, *Chaetomium rectopilum*, *C. virginicum* and *Thielavia microspora*.

Most of the remaining species were isolated in earlier investigations from self-heating materials by Fergus (12), Chang & Hudson (7), Cooney & Emerson (8), or steamed soil (28). The monthly total counts of thermophilous species showed two maxima, one in winter months, October-December, and the other in summer months, May-July. This observation of double maxima has already been reported by Evans (11).

It has been pointed out in previous studies that the fungi in the atmosphere come primarily from surfaces of growing vegetation and other debris. This view was introduced by Gregory (13) and confirmed by Dransfield (10), Moustafa (16), Mishra (19). Those fungi are carried by air currents from several directions. Therefore, the characteristics of the fungal air-spores of a given area are governed by a number of factors, the most important of which are the density, type, and nature of plant cover as well as the prevailing climatic conditions. Since plant cover is almost absent in Kuwait, the composition of air-spores is determined mainly by the changes in atmospheric factors and the geographic position of Kuwait in relation to the neighbouring countries. Because the state of Kuwait is typically arid with a relatively small area (18,000 km²), it is, therefore expected that most of the fungal air-spores is of exogenous origin, i.e. transported by air currents from the neighbouring countries, particularly the agricultural ones – Iran and Iraq – which are more temperate with more cereals and grasses. The high incidence of fungal spores reported twice a year, especially during March and November, when the prevailing wind direction is North-west and South-east, may give some support to this view. Other conclusive evidence of spore transport comes from the observation by Davies (9) as he reported very high and consistent concentrations of *Ustilago* and other

basidiospores in the atmosphere of Kuwait, which normally should not be present.

References

1. Barkai-Golan, R. 1959. A study of air-borne fungi in Israel. Bull. Res. Coun. Israel 6D: 247–258.
2. Barkai-Golan, R. 1961. Air-borne fungi in packing houses for citrus fruits. Bull. Res. Coun. Israel 10D: 135–141.
3. Barkai-Golan, R. & I. Clazer. 1962. Air-borne fungi in Eliat and Tel-Hashmor, Israel. J. Allergy 33: 342–348.
4. Ben-Meir-Gleuck, Y. 1952. Fungi isolated from the air of groves and packing sheds and from the skin of Shamouti Oranges. Ktavim 2–3: 134–140.
5. Blatt, H. 1962. Microbial allergy. A critical review – 1950 – May 1960. V. Ann. Allergy 20: 263.
6. Cammak, R. H. 1955. Seasonal changes in three common constituents of the air-spores of Southern-Nigeria, Lond. 179: 1270–1272.
7. Chang, Y. & H. J. Hudson. 1967. The fungi of wheat straw compost. I. Ecological studies. Trans. Br. Mycol. Soc. 50: 649–666.
8. Cooney, D. G. & R. Emerson. 1964. Thermophilic fungi. W. H. Freeman & Co. San Francisco.
9. Davies, R. R. 1969. Spore concentrations in the atmosphere at Ahmadi, a new town in Kuwait. J. Gen. Microbiol. 55: 425–432.
10. Dransfield, M. 1966. The fungal air-spores at Samaru, Northern-Nigeria. Trans. Br. Mycol. Soc. 49: 121–132.
11. Evans, H. C. 1972. Thermophilous fungi isolated from the air. Trans. Br. Mycol. Soc. 59: 516–519.
12. Fergus, C. L. 1964. Thermophilic and thermotolerant moulds and Actinomycetes of mushroom compost during peak heating. Mycologia 56: 267–284.
13. Gregory, P. H. 1961. The microbiology of the atmosphere. London, Leonard Hill (Books) Ltd.
14. Halwagy, R. & M. Halwagy. 1974. Ecological studies on the desert of Kuwait. 1. The physical environment. J. Univ. Kuwait (Sci) 1: 75–85.
15. Kramer, C. L., S. M. Pady, C. T. Rogerson & L. G. Ouye. 1959. Kansas aeromycology. II. Materials, methods and general results. Trans. Kans. Acad. Sci. 62: 184–199.
16. Moustafa, A. F. 1971. Studies on Egyptian fungi in soil and air. Ph. D. Thesis, University of Assiut, Egypt.
17. Moustafa, A. F. 1975. Osmophilous fungi in the salt marshes of Kuwait. Cand. J. Microbiol. 21: 1573–1580.
18. Moustafa, A. F. & A. A. Al-Musallam. 1976. Contribution to the fungal flora of Kuwait. Trans. Br. Mycol. Soc. 65: 547–553.
19. Mishra, R. 1972. Aeromycology of Gorakhpur IV. Periodical fluctuation of aerospores. Mycopathologia 48: 217–222.
20. Pawsey, R. G. & L. A. Heath. 1964. An investigation

- of the spore population of the air at Nottingham. I. The results of the Petri-dish trapping over one year. *Trans. Br. Mycol. Soc.* 47: 351-355.
21. Prince, H. E. & M. B. Marrow. 1937. Moulds in the etiology of asthma and hay-fever with special reference to the coastal areas of Texas. *South. med. J.* 30: 754.
 22. Prince, H. E. & M. B. Marrow. 1963. Etiologic factors in allergic diseases. Moulds. *Ann. Allergy* 21: 471.
 23. Richards, M. 1956. A Census of mould spores in the air over Britain in 1952. *Trans. Br. Mycol. Soc.* 39: 431-441.
 24. Saad, S. I. 1958. Studies in atmospheric pollen grains and fungus spores at Alexandria. II. Pollen and spore deposition in relation to weather conditions and diurnal variation in the incidence of pollen. *Egypt. J. Bot.* 1: 63-79.
 25. Saito, K. 1922. Untersuchungen über die atmosphärischen Pilzkeime. III. *Mitt-Jap. J. Bot.* 1: 1-54.
 26. Turner, P. D. 1966. The fungal air-spore of Hong Kong as determined by the agar plate method. *Trans. Br. Mycol. Soc.* 49: 255-267.
 27. Upsher, F. J. & D. A. Griffiths. 1973. Air-spora of a site in tropical Queensland, Australia. *Trans. Br. Mycol. Soc.* 61: 537-545.
 28. Warcup, J. H. 1951. Soil steaming, a selective method for the isolation of Ascomycetes from soil. *Trans. Br. Mycol. Soc.* 34: 515-518.
 29. Zaky, M. K. 1960. Studies on the dissemination of pollen grains and spores in the Cairo area. M. Sc. Thesis, Cairo University.