

Short communication

Airborne fungal spores in the coastal plain of Israel: A preliminary survey

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Abstract

Airborne spores were monitored during the years 1993–1995 in three cities along the coastal plain of Israel: Ramat Gan, Tel Aviv (Ramat Aviv) and Haifa. Seasonal fluctuations in the concentration of airborne spores were recorded. The following genera of fungi were identified: *Alternaria*, *Cladosporium*, *Coprinus*, *Curvularia*, *Drechslera*, *Diplococcum*, *Epicoccum*, *Fusarium*, *Leptosphaeria*, *Pithomyces*, *Puccinia*, *Sphacelotheca*, *Stemphylium* and *Ustilago*. Unidentified spores were very rare and in negligible numbers. The dominant airborne fungal spores were *Cladosporium* and *Alternaria*. The monthly variations in airborne spores, observed among the three cities, seem to be rather minor. The recorded levels of airborne spores were below the concentrations that are accepted as threshold levels for provocation of clinical responses. © 1997 Elsevier Science Ireland Ltd.

Keywords: Airborne spores monitoring; Fungal spores; Spore spectrum; Threshold levels

1. Introduction

Fungi are among the most common organisms in nature. Therefore, fungal spores are abundant in the indoor and outdoor atmospheres, and are inescapable in any frost-free environment. The most abundant airborne spores are *Cladosporium*, *Alternaria*, *Epicoccum*, *Drechslera*, *Stemphylium*, *Curvularia* and *Coprinus*. These represent a group of taxa of cosmopolitan fungi that can exploit virtually any organic substrate (Burge, 1985). Airborne spores have been widely recognized as allergens, and were mostly linked with the etiology of asthma. Respiratory allergy to fungal spores may affect up to 30% of the allergic human population (Gravensen, 1979). The literature that touches upon the occurrence of airborne spores in homes and in workplaces is rather extensive (Burge, 1990). However, little

is known about the potency of the various species and of the exposure levels to fungal spores, that might cause clinical responses, when encountered in the outdoor environment (Levetin et al., 1995).

The aim of the present investigation was to monitor the various genera of airborne spores, to identify the most common genera and to determine their inter- and intra-annual variations in three sites along the coastal plain of Israel: Ramat Gan, Tel Aviv (Ramat Aviv) and Haifa (Waisel et al., 1997).

2. Materials and methods

Airborne pollen and spores were monitored from January 1993 through to December 1995, using two types of instruments: Rotorod volumetric samplers (Model 87, Sampling Technologies, Los Altos Hills, CA) and Burkard pollen and spores trap (Burkard Manufacturing, Rickmansworth, Herfordshire, UK).

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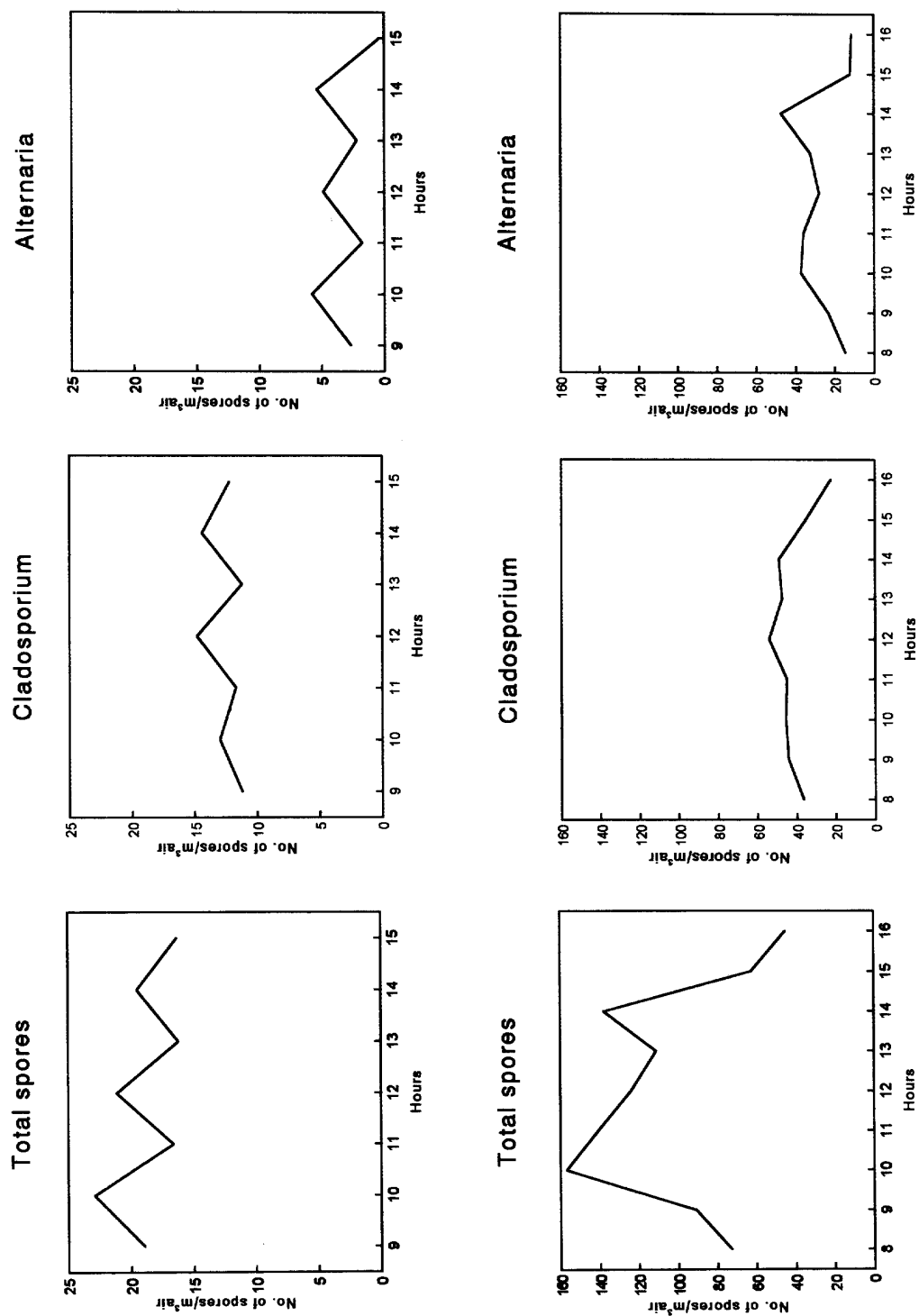


Fig. 1. Daily fluctuations in airborne spore concentrations, as recorded in Ramat Gan. Upper graphs: January 15th, 1996. Lower graphs: February 2nd, 1996.

Monitoring in Tel Aviv (Ramat Aviv) was made with the Burkard 7-day volumetric spore trap, with 10 l/min suction. The instrument was located on the roof of a two-storey building in the Tel Aviv University campus, 12 m above ground level. The tape was changed every week, and cut into seven segments, each corresponding to a daily collection of 9 h, i.e. between 08:00 and 18:00 h. The Rotorod samplers were used in Ramat Gan and Haifa. In Ramat Gan, two samplers were used at a height of 1.2 and 1.8 m above ground on a hill top. In Haifa the sampler was placed on the roof of a building (12 m height) in the center of the Carmel area. Monitoring by Rotorods was carried out once a week, twice a day at 10:30 and at noon, for 30 min each time. Spores were identified and counted, and their concentrations were expressed as weekly average concentrations per cubic meter of air. In order to get an estimation of the daily variations of spore concentration, readings, on some days, were taken with the Rotorod for 30 min every hour, between 8:00 and 16:00 h.

Identification of the spores was done by light microscopy, at a magnification of $\times 400$. Spores were identified at the genus level only.

Only negligible numbers of unidentified spores were recorded, and therefore those were omitted from the presented data.

Monitoring in Ramat Aviv was started only in 1994. Airborne spores in Haifa were not measured during August.

3. Results and discussion

Airborne spore concentrations differed somewhat during the day, but the general trend showed a reasonably steady plateau from 09:00 to 15:00 h (Comtois and Mandrioli, 1996). An example of two daily time courses, are presented in Fig. 1. Thus, as our routine measurements were taken twice a day, at noon and just before it, the reported values represent the spore concentrations during significant parts of the day. The only exceptions were of *Coprinus* and *Fusarium*, whose spores reached their highest concentrations during the early morning hours and decreased later.

Minor fluctuations in the seasonal concentration of airborne spores were noted (Fig. 2). The highest concentration was observed during the late spring and is apparently the result of the high temperatures that characterizes this season, which are ideal for fungal development (Fengxiang et al., 1991). The identified genera of fungi were: *Alternaria*, *Cladosporium*, *Coprinus*, *Curvularia*, *Drechslera*, *Diplococcum*, *Epicoccum*, *Fusarium*, *Leptosphaeria*, *Pithomyces*, *Pleospora*, *Puccinia*, *Sphacelotheca*, *Stemphylium* and *Ustilago*. The dominant airborne fungi spores and their concentra-

tions in Ramat Gan, Ramat Aviv and Haifa, during the year 1995, are shown in Table 1. The spectrum of airborne spores during the period of highest total spore

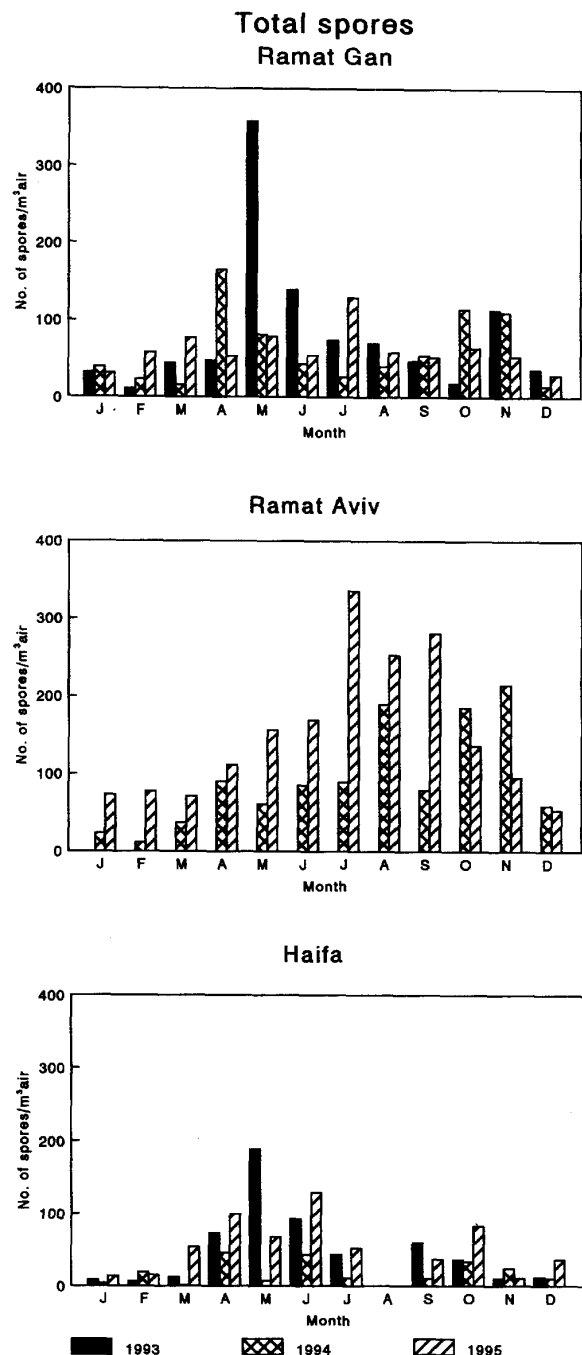


Fig. 2. Monthly average concentrations of airborne spores in Ramat Gan (1993–1995), Ramat Aviv (1994–1995) and Haifa (1993–1995). Each of the averages of Ramat Gan and Haifa is of eight measurements.

Table 1

Monthly average concentrations of airborne spores during 1995, in Ramat Gan, Ramat Aviv and Haifa (Number of spores per m³ of air)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ramat Gan												
<i>Alternaria</i>	4	6	5	7	10	8	14	5	6	3	2	2
<i>Cladosporium</i>	12	73	45	18	38	37	88	36	32	34	35	32
<i>Epicoccum</i>	1	1	1	0	1	0	0	1	0		1	10
<i>Drechslera</i>		1	2	1	1	1	1	1	1	2	2	21
<i>Coprinus</i>	2	4	2	1	1	1	1	2	2	3	9	1
<i>Fusarium</i>	0	1	0	0	0	0	0	0	0	0	0	0
<i>Pleospora</i>	4	5	2	1	1	1	0	0	0	1	1	1
<i>Puccinia</i>	1	1	1	2	1	1	6	2	4	3	4	7
<i>Sphacelotheca</i>	5	3	9	7	13	1	6	4	2	8	4	1
<i>Stemphylium</i>	2	7	7	8	2	4	1	3	1	1	2	6
Ramat Aviv												
<i>Alternaria</i>	9	7	5	15	44	35	39	22	15	7	10	5
<i>Cladosporium</i>	21	17	28	37	54	96	232	141	143	65	38	26
<i>Epicoccum</i>	1	1	1	1	2	1	1	1	1	1	1	1
<i>Drechslera</i>	2	2	2	4	7	8	9	18	79	21	3	3
<i>Coprinus</i>	5	7	4	2	3	4	6	4	5	3	3	5
<i>Fusarium</i>	6	21	8	6	1	2	1	1	1	1	2	1
<i>Pleospora</i>	12	6	2	1	1	1	1	1	3	1	1	3
<i>Puccinia</i>	5	5	7	5	8	7	9	8	12	11	5	5
<i>Sphacelotheca</i>	5	3	8	23	10	29	19	22	11	8	6	5
<i>Stemphylium</i>	4	3	4	7	23	6	4	1	2	1	2	3
Haifa												
<i>Alternaria</i>	2	1	11	13	5	13	4	—	2	4	1	3
<i>Cladosporium</i>	4	7	25	44	32	72	36	—	28	46	7	29
<i>Epicoccum</i>	0	0	1	0	0	0	1	—	0	0	0	1
<i>Drechslera</i>	1	0	1	1	1	1	0	—	0	1	1	0
<i>Coprinus</i>	1	1	0	1	2	1	0	—	1	1	0	5
<i>Fusarium</i>	0	1	1	0	0	1	0	—	0	0	0	0
<i>Pleospora</i>	1	2	3	0	0	0	1	—	0	1	0	0
<i>Puccinia</i>	1	1	1	2	1	9	0	—	5	14	3	5
<i>Sphacelotheca</i>	0	0	0	18	25	12	7	—	1	7	0	2
<i>Stemphylium</i>	3	1	13	8	1	4	1	—	1	2	0	1

Each of the averages of Ramat Gan and Haifa is of eight measurements.

concentrations is shown in Fig. 3. *Cladosporium* spores were the most abundant among the genera that were identified in the present study, reaching almost 75% of the total count in Ramat Gan, but less than 50% in Haifa (Fig. 3). The maximal daily concentrations of *Cladosporium* spores were recorded in Ramat Aviv during July, when 540 spores/m³ of air were recorded. Ramat Aviv is near the sea and air humidity there is rather high. *Cladosporium* is an important component of the airborne population of spores, and is known to be allergenic (Levetin et al., 1995). In Denmark, the weekly clinical symptoms and medication scores were positively correlated with airborne spore counts of *Cladosporium* (Malling et al., 1987).

Airborne *Cladosporium* and *Alternaria* spores were constantly recorded during the whole year, though with significant seasonal variations. The highest concentrations of airborne *Cladosporium* spores were also recorded during the summer and autumn months, July–November (Fig. 4). The concentrations of air-

borne spores of *Cladosporium* were positively correlated with temperature and negatively correlated with humidity (Ballero et al., 1992).

Alternaria is known to be one of the main genera that are implicated for respiratory allergy (Beguin, 1995). The maximal daily concentrations of *Alternaria* spores was recorded in May in Haifa, reaching a value of 81 spores/m³ of air. Significant monthly fluctuations of airborne spores of *Alternaria* (1–81 spores/m³ of air) were observed in Haifa during the years 1993–1995. Similarly large variations in the concentrations of *Alternaria* spores were observed during 1995 in Ramat Aviv where the highest concentrations were recorded between May and July, reaching values of 35–44 spores/m³ of air (Fig. 5).

The concentrations of *Alternaria* spores were above 10 spores/m³ of air throughout the summer (from April to November in Ramat Aviv, from April to September in Haifa and from April to July in Ramat Gan).

During the autumn the relative humidity of the air decreases, thus, allowing other, relatively more thermophilic and xerophilic genera of fungi, e.g. *Epicoccum*, *Drechslera* and *Stemphylium* to grow (Ballero et al., 1992; Beguin, 1995).

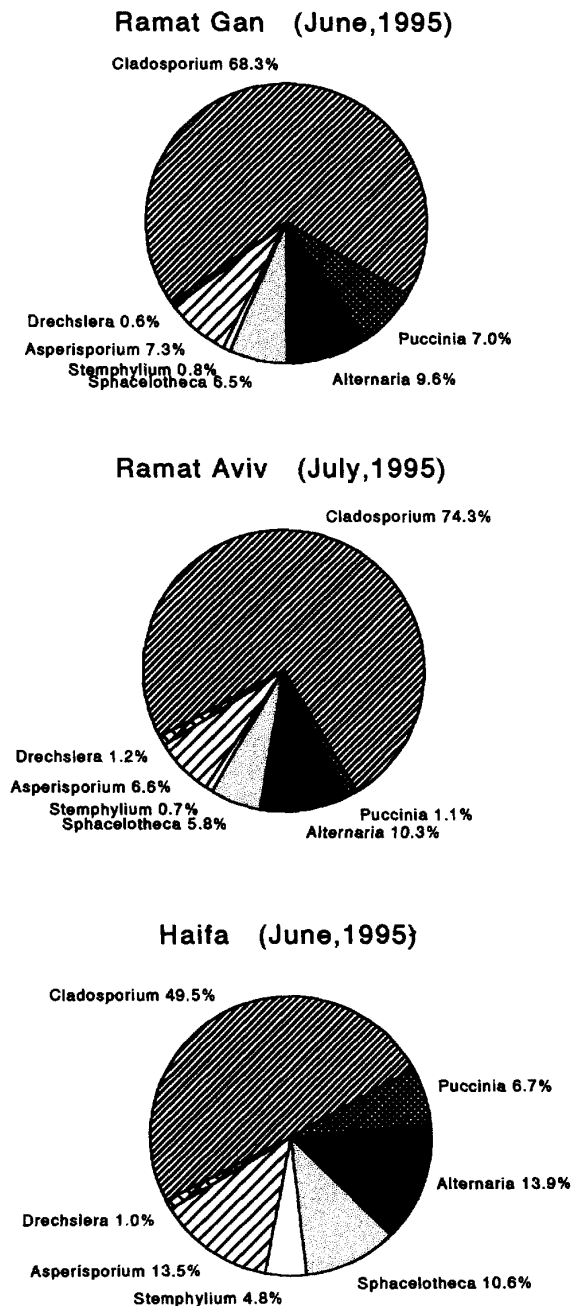


Fig. 3. Distribution of the various species of airborne spores in Ramat Gan, Ramat Aviv and Haifa in 1995, during the month with the highest spore concentrations. Percent of the total number of spores.

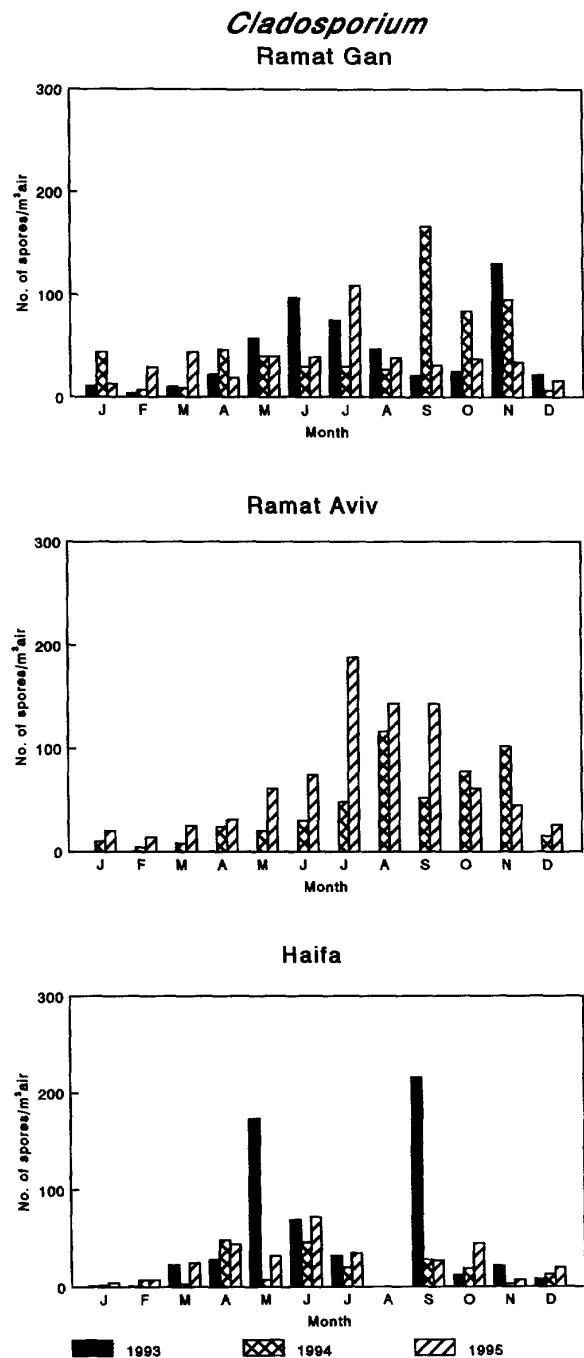


Fig. 4. Monthly average concentrations of airborne spores of *Cladosporium* in Ramat Gan (1993–1995), Ramat Aviv (1994–1995) and Haifa (1993–1995). Each of the averages of Ramat Gan and Haifa is of eight measurements.

In spite of the distances between the three stations, only relatively small differences in the concentrations of airborne spores were found among the three cities. The

results confirm that the most common airborne fungi spores were those of *Cladosporium* and *Alternaria* which are dominant in arid and semi-arid regions (Barkai-Golan et al., 1977; Caretta, 1992).

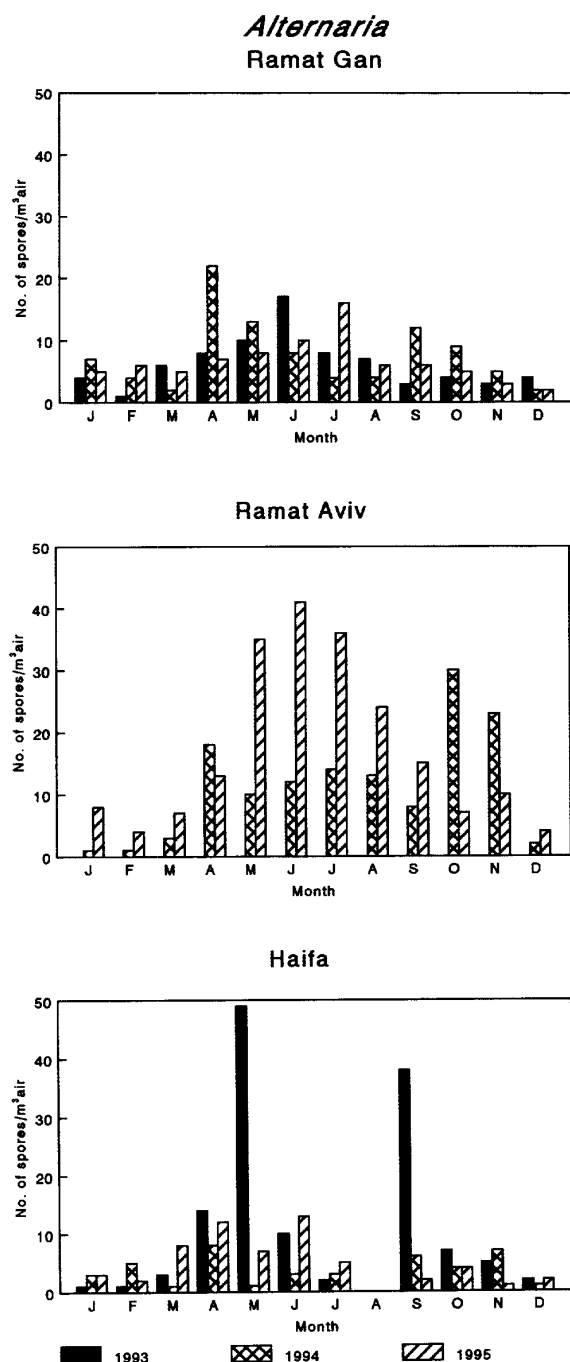


Fig. 5. Monthly average concentrations of airborne spores of *Alternaria* in Ramat Gan (1993–1995), Ramat Aviv (1994–1995) and Haifa (1993–1995). Each of the averages of Ramat Gan and Haifa is of eight measurements.

The threshold concentrations of airborne allergens, for the induction of clinical symptoms, are practically unknown. The rule of the thumb is that a concentration of 100 spores of *Alternaria* per m³ of air and 3000 spores of *Cladosporium* are reasonable estimates for the concentrations which may induce clinical symptoms by those taxa (Dhillon, 1991; Caretta, 1992). The maximal daily concentrations of *Cladosporium* and *Alternaria* spores which were recorded in the present study, were significantly lower, than the suggested critical concentrations. However, one has to remember that the clinical responses of the patients do not depend only on the concentrations of *Alternaria* or *Cladosporium* (Reese et al., 1994). Half of all episodes of increased pulmonary complaints by asthmatic patients coincided with a total fungal spores peak of more than 500 spores/m³ of air (Beaumont et al., 1985). Thus, on the basis of the presented data, it seems that in the coastal plain of Israel, the air contamination with fungal spores is below the threshold level and fungal spores do not constitute a common and serious cause for allergies.

4. Conclusions

In spite of the short time of the current sampling with the Rotorod samplers, it seems that the recorded maximal concentrations of airborne spores of *Cladosporium* and *Alternaria*, in the outdoor environment, were rather low. The seasonal concentrations of airborne spores of *Cladosporium* and *Alternaria* were similar to the concentrations which were found in Rehovot during the years 1973–1974 (Barkai-Golan et al., 1977), in spite of the different method of spore collection that was used at that time. Thus, the contamination of the air with airborne spores remained rather constant during the last 20 years. The obtained figures are lower than the accepted threshold concentrations, that are believed provoke clinical responses (Dhillon, 1991; Caretta, 1992). However, in homes and some workplaces, e.g. farms, plant nurseries, flower shops, flour mills, etc., the concentrations of airborne spores are probably much higher, because of the presence of proper substrates, the higher relative humidity and temperature, and because of the lack of direct sunshine (Burge, 1990; Fengxiang et al., 1991; Verhoeff et al., 1992).

Thus, unlike the case of pollen grains (Waisel et al., 1997), fungal spores do not seem to be a major and general threat for allergic people. Nevertheless, their low concentrations in the open air environment does not exclude their potential danger in closed environments.

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