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Airborne fungal spores at the Belgrad forest near the city of Istanbul (Turkey) in the year 2001 and their relation to allergic diseases

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The aim of this study was to investigate the relationship between airborne fungal spores and allergic diseases; for this reason, the airborne fungal spores that were obtained from five different locations of Belgrad Forest were isolated, determined and studied quantitatively.

Totally 120 samples were examined by using the Petri Plate Gravitational Method, and fungi obtained from these samples were isolated and 600 colonies were counted. By identification of these isolations, 13 genera (*Mucor, Rhizopus, Absidia, Aspergillus, Penicillium, Trichoderma, Trichothecium, Stemphylium, Cladosporium, Alternaria, Ulocladium, Aureobasidium* and *Fusarium)*, 25 species and 10 different sterile fungi were determined. The identifications of these fungi were made according to their microscopic, macromorphological features and references.

In this investigation the airborne fungal spores in the different locations of Belgrad Forest near Istanbul during the year 2001 are studied. The importance of these airborne fungal spores which may cause allergy and asthma have been emphasized.

Materials and methods

Belgrad Forest is situated in Çatalca peninsula within the geographical region of Marmara between 28° 54′ 00″–29° 00′ 00″ East longitudes (Greenwich) and 41° 09′ 0″ – 42° 12′ 30″ North latitudes. The highest point of Belgrad Forest (Kartaltepe) is 230 m above sea level and the lowest point of Belgrad Forest (Kurudere) is 40 m above sea level (KANTARCI 1980).

The study area has a "humid, mesothermal climate, close to oceanic effect, with a moderate water deficit in summer" (B_3, B'_1, Sb'_4) according to Thornthwaite water-balance method (Table 1) (ERUZ 1980).

Sampling locations and the dominant tree species are shown in Table 2. These locations were covered with *Pinus nigra* and *Quercus* species.

120 samples were taken from five different locations in the Belgrad Forest in 2001, and were studied by cultivation and microscopic methods. The samples were collected from five different locations of the Belgrad Forest and 24 samples were taken in each location during the year 2001 (Table 3).

In the process of fungi isolating from the samples the Petri Plate Gravitational Method (SAVINO and CARETTA 1992, ROSAS *et al.* 1993) was employed. A pair of Petri dishes containing Sabouraud Dextrose Agar (SDA) were exposed to the air for 15 min in the sampling locations (ÇOLAKOĞLU 1996a). At the end of this period the covers of the Petri dishes were closed so as not to allow contact of the contents with the atmosphere. This procedure was carried out twelve times in the morning hours (06^{00} a.m. – 08^{00} a.m.) as is done in the literature (DAVIES 1969a, ASAN *et al*. 2002) at a height of 1.5 m above the ground during the year of 2001 at each of the five locations (Table 3). Each sample was taken on the 15^{th} day of every month.

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Table 1
Some climatic data of Bahçeköy Meteorology Station (1948–1977)

Climate Elements	Months												Annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Average temperature °C	4.7	5.0	5.9	10.4	15.0	19.2	21.6	21.6	17.8	14.2	10.9	6.9	12.8
Maximum temperature °C	22.0	23.5	27.9	32.2	34.0	36.6	36.6	39.7	35.1	31.7	25.8	21.4	39.7
Daily	1948	1958	1952	1952	1958	1955	1966	1958	1961	1952	1961	1963	
Minimum temperature °C	−15.8	−9.2	−8.4	−2.6	1.7	5.0	8.9	5.7	4.6	0.6	−7.7	−10.4	−15.8
Daily	1963	1956	1949	1963	1965	1962	1950	1949	1970	1972	1948	1967	
Average rain mm	157.8	108.4	114.4	56.2	42.8	40.2	30.3	51.4	73.4	111.2	128.1	171.8	1086.0
Maximum rain mm	69.9	50.5	85.2	63.1	132.3	87.2	66.6	107.3	80.4	101.2	77.2	65.5	132.2
Daily													
Average relative humidity %	84	82	83	82	82	80	79	79	81	83	87	85	82
Minimum relative humidity %	36	33	22	17	28	23	23	25	25	24	36	34	17
Number of freezing days	11	7	7	1	–	–	–	–	–	–	2	5	33
Number of snowy days	4.4	4.5	2.0		–	–	–	–	–	–	0.3	1.5	12.7
Side of dominant wind	NW-NE	NW-NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NW-NE

Table 2
Sampling locations and the dominant tree species

Sampling locations	Exposure	Dominant trees
Pinus nigra Stand (Water Dams Area)	East	*Pinus nigra* ARNOLD
Pinus nigra Stand (Near Atatürk Arboretum)	North	*Pinus nigra* ARNOLD
Quercus Stand (Environs of Valide Sultan Dam)	Northeast	*Quercus petraea* (MATTUSCHKA) Lieb.
Quercus Stand (Subdivision Number 102, Soğuksu)	East	*Quercus frainetto* TEN.
Quercus Stand (Garden of Forestry Faculty)	East	*Quercus* spp.

Table 3
Sampling locations and the number of samples taken

Number of sampling locations	The number of PETRI dishes in one sampling	The number of samples taken monthly	The total number of PETRI dishes
1	2	12	24
2	2	12	24
3	2	12	24
4	2	12	24
5	2	12	24
Total	10	60	120

The Petri dishes were incubated at 25 °C. Of the fungi colonies which formed after an incubation period of 7–10 days at 25 °C, fungi were isolated and cultivated in Malt Extract Agar (MEA), CZAPEK DOX Agar (CDA) and Potato Dextrose Agar (PDA) (SMITH 1971). All media contained 30 mg/l streptomycin to suppress bacteria (MARTIN 1950). Following another 7–10 days incubation period at 25 °C, the preparations were dyed with picric acid in a medium of lactophenol solution (by saturating with picric acid a lactophenol solution containing phenol, lactic acid, glycerol and distilled water) (SMITH 1971). In the preparations extra-thin lamellae were used and the identifications of fungi were carried out as in the literature (RAPER *et al*. 1949, RAPER and FENNEL 1965, SIMMONS 1967, RIFAI 1969, ZYCHA and SIEPMANN 1969, BOOTH 1971, ELLIS 1971, SMITH 1971, ÇOLAKOĞLU 1990).

Results

In this study, the airborne fungal spores in the air collected at five different locations in the Belgrad Forest area were studied quantitatively. During the twelve month period of the study, 120 samples were processed by using the Petri Plate Gravitational Method and from these samples obtained fungi were isolated and 600 colonies were counted. By identification of these isolations, 13 genera *(Mucor*, *Rhizopus, Absidia, Aspergillus, Penicillium, Trichoderma, Trichothecium, Stemphylium, Cladosporium, Alternaria, Ulocladium, Aureobasidium* and *Fusarium)* (Table 4) and 5 species in the Zygomycetes class (Mucorales), 20 species in the form class Deuteromycetes (Fungi Imperfecti) (Moniliales), that is, a total of 25 species *(M. jansseni*, *M. hiemalis*, *M. globosus*, *R. nigricans*, *Abs. spinosa*, *Asp. candidus*, *Asp. fumigatus*, *Asp. flavus*, *Asp. repens*, *Asp. niger*, *P. chrysogenum*, *P. expansum*, *P. brevicompactum*, *P. simplicissimum*, *P. frequentans*, *Trd. viride*, *Trt. roseum*, *S. macrosporoideum*, *C. herbarum*, *C. cladosporioides*, *Alt. alternata*, *U. atrum*, *Aur. pullulans*, *F. oxysporum* and *F. moniliforme)* and 10 sterile fungi were isolated (Tables 5–9). 12 species from *P. nigra* stand, 23 species from *Quercus* stand, and 3 species *(R. nigricans*, *C. cladosporioides* and *S. macrosporoideum)* were isolated from the air of both *P. nigra* and *Quercus* stands (Tables 5–9).

Table 4
The number of colonies of the fungi genera and the percentages of these colony counts in the total count which were obtained in the area of Belgrad Forest in the year 2001

Fungi	Sampling locations					
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of genera in the total count of colonies	1	2	3	4	5
Mucor MICH. ex FR.	1	2	2	–	–	2
Rhizopus EHRENBERG	9	14	12	8	14	6
Absidia VAN TIEGHEM	0.333	2	–	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES						
Aspergillus LINK	24.333	20	14	28	24	60
Penicillium LINK	19	24	24	22	20	24
Trichoderma PERS. ex FR.	7.333	18	10	16	–	–
Trichothecium LINK	0.333	–	–	–	2	–
Stemphylium WALLR.	1	2	–	–	4	–
Cladosporium LINK	17	–	16	18	20	48
Alternaria NEES ex FR.	1	–	–	–	–	6
Ulocladium PREUSS	1	–	–	–	–	6
Aureobasidium VIALA and BOYER	3	–	–	6	6	6
Fusarium LINK ex FR.	6.333	–	12	8	12	6
No. of samples: 120		24	24	24	24	24
No. of colonies: 600		102	94	116	116	172
No. of genera: 13		7	7	7	8	9

Notes for locations:
1. *Pinus nigra* Stand (Water Dams Area)
2. *Pinus nigra* Stand (Near Atatürk Arboretum)
3. *Quercus* Stand (Environs of Valide Sultan Dam)
4. *Quercus* Stand (Subdivision Number 102, Soğuksu)
5. *Quercus* Stand (Garden of Forestry Faculty)

Table 5
The number of colonies of the fungi species and the percentages of these colony counts in the total count which were obtained in the *Pinus nigra* stand (Water Dams Area) in the Belgrad Forest in the year 2001

Fungi	The number of colonies identified/sample/month											
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of species in the total count of colonies	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mucor jansseni LENDNER	1.960	–	–	–	–	2	–	–	–	–	–	–	–
Rhizopus nigricans EHRENBERG	13.725	–	–	2	2	2	2	2	2	2	–	–	–
Absidia spinosa LENDNER	1.960	–	–	–	–	–	2	–	–	–	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES													
Aspergillus candidus LINK	19.607	–	2	2	2	2	2	2	2	2	2	2	–
Penicillium chrysogenum THOM	23.529	2	2	2	2	2	2	2	2	2	2	2	2
Trichoderma viride PERS. ex FR.	17.647	2	2	2	2	2	2	2	2	2	–	–	–
Stemphylium macrosporoideum (BERKELEY and BROOME) SACC.	1.960	–	–	–	–	2	–	–	–	–	–	–	–
Sterile 1	7.843	–	–	–	2	2	2	2	–	–	–	–	–
Sterile 2	11.764	–	–	–	2	2	2	2	2	2	–	–	–
No. of samples: 24		2	2	2	2	2	2	2	2	2	2	2	2
No. of colonies: 102		4	6	8	12	16	14	12	10	10	4	4	2
No. of species: 7		2	3	4	4	6	5	4	4	4	2	2	1

Table 6
The number of colonies of the fungi species and the percentages of these colony counts in the total count which were obtained in the *Pinus nigra* stand (Near Atatürk Arboretum) in the Belgrad Forest in the year 2001

Fungi		The number of colonies identified/sample/month											
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of species in the total count of colonies	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mucor hiemalis WEHMER	2.127	–	–	–	–	–	2	–	–	–	–	–	–
Rhizopus nigricans EHRENBERG	12.765	–	–	–	2	2	2	2	2	2	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES													
Aspergillus fumigatus FRESENIUS	14.893	2	2	2	–	–	–	–	–	2	2	2	2
Penicillium expansum (LINK) THOM	25.531	2	2	2	2	2	2	2	2	2	2	2	2
Trichoderma sp.	10.638	–	–	2	2	2	2	2	–	–	–	–	–
Cladosporium herbarum (PERS.) LINK ex S. F. GRAY	17.021	–	–	–	2	2	2	4	2	2	2	–	–
Fusarium sp.	12.765	–	–	–	2	2	2	–	–	2	2	2	–
Sterile 1	2.127	2	–	–	–	–	–	–	–	–	–	–	–
Sterile 2	2.127	–	–	2	–	–	–	–	–	–	–	–	–
No. of samples: 24		2	2	2	2	2	2	2	2	2	2	2	2
No. of colonies: 94		6	4	8	10	10	12	10	6	10	8	6	4
No. of species: 5		2	2	2	3	3	4	3	3	4	3	2	2

Table 7
The number of colonies of the fungi species and the percentages of these colony counts in the total count which were obtained in the *Quercus* stand (Environs of Valide Sultan Dam) in the Belgrad Forest in the year 2001

Fungi		The number of colonies identified/sample/month											
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of species in the total count of colonies	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rhizopus nigricans EHRENBERG	6.896	–	–	2	2	2	2	–	–	–	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES													
Aspergillus flavus LINK ex GRAY	24.137	2	2	2	4	4	2	2	2	2	2	2	2
Penicillium brevicompactum DIERCKX	18.965	2	2	2	2	2	2	2	2	2	2	–	2
Trichoderma sp.	13.793	–	–	2	2	2	2	2	2	2	2	–	–
Cladosporium herbarum (PERS.) LINK ex S. F. GRAY	15.517	–	–	–	2	2	2	4	4	2	2	–	–
Aureobasidium pullulans (DE BARY) ARNAUD	5.172	–	–	–	–	–	2	2	2	–	–	–	–
Fusarium oxysporum SCHLECHT.	6.896	–	–	–	2	2	2	2	–	–	–	–	–
Sterile 1	5.172	2	2	–	–	–	–	–	–	–	–	–	2
Sterile 2	3.448	–	–	2	–	–	2	–	–	–	–	–	–
No. of samples: 24		2	2	2	2	2	2	2	2	2	2	2	2
No. of colonies: 116		6	6	10	16	14	16	14	12	8	8	2	6
No. of species: 6		2	2	3	5	5	6	5	4	3	3	1	2

Table 8
The number of colonies of the fungi species and the percentages of these colony counts in the total count which were obtained in the *Quercus* stand (Subdivision Number 102, Soğuksu) in the Belgrad Forest in the year 2001

Fungi		The number of colonies identified/sample/month											
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of species in the total count of colonies	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Rhizopus nigricans EHRENBERG	12.068	–	–	2	2	2	2	2	2	2	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES													
Aspergillus flavus LINK ex GRAY	20.689	2	2	2	2	2	2	2	2	2	2	2	2
Penicillium simplicissimum (OUDEMANS) THOM	17.241	2	2	2	2	2	2	2	2	2	2	–	–
Trichothecium roseum LINK	1.724	–	–	–	–	2	–	–	–	–	–	–	–
Stemphylium macrosporoideum (BERKELEY and BROOME) SACC.	3.448	–	–	–	–	2	–	–	–	2	–	–	–
Cladosporium herbarum (PERS.) LINK ex S. F. GRAY	17.241	–	–	–	4	4	2	4	2	2	2	–	–
Aureobasidium pullulans (DE BARY) ARNAUD	5.172	–	-–	–	–	2	2	2	–	–	–	–	–
Fusarium sp.	10.344	–	–	–	2	2	2	2	2	2	–	–	–
Sterile 1	6.896	2	2	–	–	–	–	–	–	–	–	2	2
Sterile 2	5.172	–	2	2	–	–	–	–	–	–	–	2	–
No. of samples: 24		2	2	2	2	2	2	2	2	2	2	2	2
No. of colonies: 116		6	8	8	12	18	12	14	10	12	6	6	4
No. of species: 7		2	2	3	4	7	5	5	4	5	3	1	1

Table 9
The number of colonies of the fungi species and the percentages of these colony counts in the total count which were obtained in the *Quercus* stand (Garden of Forestry Faculty) in the Belgrad Forest in the year 2001

Fungi		The number of colonies identified/sample/month											
CLASS: ZYGOMYCETES ORDER: MUCORALES	% of species in the total count of colonies	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mucor globosus FISCHER	1.162	–	–	–	–	–	2	–	–	–	–	–	–
Rhizopus nigricans EHRENBERG	3.488	–	–	–	–	2	2	2	–	–	–	–	–
FORM CLASS: DEUTEROMYCETES FORM ORDER: MONILIALES													
Aspergillus repens DE BARY	13.953	2	2	2	2	2	2	2	2	2	2	2	2
Aspergillus niger VAN TIEGHEM	20.930	2	2	2	4	4	4	4	4	4	2	2	2
Penicillium frequentans WESTLING	13.953	2	2	2	2	2	2	2	2	2	2	2	2
Cladosporium cladosporioides (FRESEN.) DE VRIES	27.906	4	4	4	4	4	4	4	4	4	4	4	4
Alternaria alternata (FR.) KEISSLER	3.488	–	–	–	–	2	2	–	–	2	–	–	–
Ulocladium atrum PREUSS	3.488	–	–	–	–	2	2	–	–	2	–	–	–
Aureobasidium pullulans (DE BARY) ARNAUD	3.488	–	–	–	–	–	2	2	2	–	–	–	–
Fusarium moniliforme SHELDON	3.488	–	–	–	–	–	2	–	–	2	2	–	–
Sterile 1	2.325	–	2	2	–	–	–	–	–	–	–	–	–
Sterile 2	2.325	2	–	–	–	–	–	–	–	–	–	–	2
No. of samples: 24		2	2	2	2	2	2	2	2	2	2	2	2
No. of colonies: 172		12	12	12	12	18	24	16	14	18	12	10	12
No. of species: 10		4	4	4	4	7	10	6	5	7	5	4	4

Discussion

Pathogenic microorganisms that are disseminated mainly through the air are either intrinsically resistant to desiccation and the other rigors of the atmosphere, or they are protected by the droplets or particles in or on which they are transported or else they are so numerous that some survive long enough to infect fresh hosts (CARPENTER 1977).

Systemic fungus infections illustrate a different type of airborne disease. The fungi are not transmitted from one individual to another. They are soil saprophytes, and when they become suspended in the air on particles of dust, they may be scattered and inhaled by man. They produce primary pulmonary infections, which may generalize and infect many parts of the body (CARPENTER 1977).

A total of 13 genera, 25 species and 10 different sterile fungi were identified in this study (Tables 4–9). The majority of the fungi isolated were of the form class Deuteromycetes (Fungi imperfecti), from the Belgrad Forest.

It is important to note that fungi show differences in species relative to their locations. The relative humidity of the air and temperature are important factors in fungal growth (AGARWAL and SHIVPURI 1969, DI GIORGIO *et al*. 1996). The minimum relative humidity in the air may be 50–65% for fungal growth (GALLO 1985). According to DAVIES (1960) fungi such as *A. repens* develop at relative humidities of 85% and *Absidia* and *Mucor* species when the humidity reaches 93.7% (DAVIES 1969b). Temperatures as low as –7 °C and up to 50 °C may be suitable (GALLO 1985). Optimal limiting values of temperature may be between 20–35 °C. *Penicillium* species are seen commonly in cold climates (WAKSMAN 1944). *C. herbarum* species reproduces at temperatures between –6 °C minimum and 20 °C maximum (ÇENGEL 1994). The effect of light on the growth of fungi is negative but may not be important (GALLO 1969). Air humidity and air velocity are significant factors for release of fungal spores in the air (PASANEN *et al*. 1991).

A summary of all fungi isolated is listed in Tables 5–9. In the air, *Aspergillus* (24.333%), *Penicillium* (19%), *Cladosporum* (17%) and *Rhizopus* (9%) (Table 4) were the most populated genera. *C. cladosporioides* (27.906 %), *P. expansum* (25.531%), *Asp. flavus* (24.137% and 20.689%), *P. chrysogenum* (23.529%), *Asp. niger* (20.930%), *Asp. candidus* (19.607%), *P. brevicompactum* (18.965%), *Trd. viride* (17.647%), *P. simplicissimum* (17.241%), *C. herbarum* (17.241%, 17.021% and 15.517%), *Asp. fumigatus* (14.893 %), *Asp. repens* (13.953%), *P. frequentans* (13.953%), *Trid.* sp. (13.793%) and *R. nigricans* (13.725%, 12.765% and 12.068%) were the most frequently encountered species determined in the study at the locations of the research area (Tables 5–9).

The fungi which were commonly isolated in this study are saprotrophic soilborne species and, according to ÇOLAKOĞLU (2001), they were isolated from the soil of Belgrad Forest. These species of fungi are *M. jansseni, M. globosus, M. hiemalis, R. nigricans, Abs. spinosa, Asp. repens, Asp. fumigatus, Asp. flavus, Asp. niger, Asp. candidus, P. frequentans, P. simplicissimum, P. chrysogenum, P. brevicompactum, P. expansum, Trd. viride, Trt. roseum, S. macrosporoideum, C. herbarum, Alt. alternata, U. atrum, F. oxysporum* and *F. moniliforme.*

It may be said that the genera *Aspergillus, Penicillium*, *Cladosporum* and *Alternaria* (PEAT *et al*. 1993) should always be considered as a cause of fungal allergy. Many of the species of fungi found in the air at five different locations at Belgrad Forest are known to cause allergy *(R. nigricans, Mucor*, *Asp. repens, Asp. fumigatus, Asp. flavus, Asp. niger, P. frequentans, P. chrysogenum, P. expansum, Trt. roseum, C. herbarum, C. cladosporioides, Alt. alternata, Aur. pullulans* and *Fusarium)* (Tables 4–9) (DAVIES 1969a, ÖZKARAGÖZ 1969, Institute Pasteur 1976, AUGER *et al*. 1994, ÇOLAKOĞLU 1996a, b, c, ASAN *et al.* 2002).

According to DAVIES (1959) the results for *Cladosporium* are typical, and show that larger numbers of spores are detached by air currents containing minute water droplets than

by air currents of the same velocity without droplets. There are important studies on this subject by DAVIES *et al*. (1963) and DAVIES (1974).

ÇOLAKOĞLU (2002) isolated an allergenic microfungus *Asp. niger* from the soil of Belgrad Forest. It was extracted and some toxicity tests were carried out in order to determine its toxic effects on mice. It was made certain that the *Asp. niger* extract was sterile and that, as the experiments made on 10 mice proved, it was not toxic.

Belgrad Forest's humid, mesothermal climate presents a favorable habitat for the reproduction of fungi. Consequently, there must be a high percentage of airborne fungi in the air which cause allergy and asthma (BLASER 1989, GERRITSEN *et al*. 1990); also, there may be fungi of different genera and species. Identifying them will be a contribution to health science.

References

AGARWAL, M. K. and SHIVPURI, D. N., 1969. Studies on the allergenic fungal spores of the Delhi, India, metropolitan area. J. Allerg, **44**, 193–203.

ASAN, A., SEN, B. and SARICA, S., 2002. Airborne fungi in urban air of Edirne city (Turkey). Biologia, **57**, 59–68.

AUGER, P. L., GOURDEAU, P. and MILLER, J. D., 1994. Clinical experience with patients suffering from a chronic fatigue-like syndrome and repeated upper respiratory infections in relation to airborne moulds. Am. J. Ind. Med., **25**, 41–42.

BLASER, K., 1989. Regulatory processes in allergy and asthma. Proceedings of the Symposium Celebrating the Foundation of the Swiss Institute of Allergy and Asthma Research, Davos, June 17, 1989. Introduction. Internat. Arch. Allergy and Appl. Immunology, **90**, 1–2.

BOOTH, C., 1971. The Genus *Fusarium*. Commonwealth Mycol. Inst. Kew, Surrey, England.

CARPENTER, P. L., 1977. Microbiology. Fourth Edition. W.B. Saunders Comp., Philadelphia, London, Toronto.

ÇENGEL, M., 1994. Toprak Biyolojisi. Ege Üniv. Ziraat Fak. Ofset Basımevi, Bornova-İzmir.

ÇOLAKOĞLU, G., 1990. Belgrad ormanındaki kesilmiş canlı ağaçların kabuklarından izole edilen küf mantarları üzerine araştırmalar (Investigations into isolated fungi mould from the barks of cut living trees from Belgrad forest). İstanbul Üniv. Orman Fak. Derg. (Review of the Faculty of Forestry, University of Istanbul) Seri A, **40**, 132–155.

ÇOLAKOĞLU, G., 1996a. The variability of fungal flora in the air during morning and evening 1994. J. Basic Microbiol., **36**, 393–398.

ÇOLAKOĞLU, G., 1996b. Fungal spore concentrations in the atmosphere at the Anatolia quarter of Istanbul, Turkey. J. Basic. Microbiol.. **36**, 155–162.

ÇOLAKOĞLU, G., 1996c. Mould counts in the atmosphere at the Europe quarter of Istanbul, Turkey. J. Basic Microbiol., **36**, 389–392.

ÇOLAKOĞLU, G., 2001. İstanbul/Belgrad ormanında karaçam (*Pinus nigra* ARNOLD) ve meşe (*Quercus* spp.) meşcerelerinin topraklarındaki mikrofungus floraları ve bunların karşılaştırılması üzerine bir çalışma (A comparative study on microfungi flora in the soils of *Pinus nigra* ARNOLD and *Quercus* spp. stands in Belgrad forest near Istanbul). İstanbul Üniv. Orman Fak. Derg. (Review of the Faculty of Forestry, University of Istanbul) Seri A, **51**, 95–116.

ÇOLAKOĞLU, G., 2002. Extraction of *Aspergillus niger* VAN TIEGHEM, an allergenic microfungus, and application of toxicity tests. Türk Mirobiyol. Cem. Derg. (J. Turk. Microbiol. Soc.), **32**, 286–289.

DAVIES, R. R., 1959. Detachment of conidia by cloud droplets. Nature, **183**, 1695.

DAVIES, R. R., 1960. Viable moulds in house dust. Trans. Br. Mycol. Soc., **43**, 616–630.

DAVIES, R. R., DENNY, M. J. and NEWTON, L. M., 1963. A comparison between the summer and autumn air-spores at London and Liverpool. Acta Allergol., **18**, 131–147.

DAVIES, R. R., 1969a. Climate and topography in relation to aero-allergens at Davos and London. Acta Allergol., **24**, 396–409.

DAVIES, R. R., 1969b. Spore concentrations in the atmosphere at Ahmadi, a new town in Kuwait. J. Gen. Microbiol., **55**, 425–432.

DAVIES, R. R., 1974. Aerobiology and atopy. British Journal of Dermatology, **90**, 101–105.

DI GIORGIO, C., KREMPFF, A., GUIRAUD, H., BINDER, P., TIRET, C. and DUMENIL, G., 1996. Atmospheric pollution by airborne microorganisms in the city of Marseilles. Atmos. Environ., **30**, 155–160.

ELLIS, M. B., 1971. Dematiaceous Hyphomycetes. Commonwealth Mycol. Inst. Kew, Surrey, England.

ERUZ, E,. 1980. Belgrad Ormanı'ndaki Meşe ve Kayın Ekosistemlerinin Bazı Önemli Kimyasal ve Fiziksel Toprak Özelliklerine İlişkin Araştırmalar (Untersuchungen über manche chemische und physikalische Eigenschapten der Böden unter den Eichen- und Buchen-Ökosystemen im Belgrader Wald). İstanbul Üniv. Orman Fak. Yayın. İ.Ü. Yayın No.2641, Orman Fak. Yayın No. 280, İstanbul.

GALLO, F., 1969. Gli agenti biologici nemici delle biblioteche, metodi di prevenzione e di lotta. Bollettino dell' ICPL.

GALLO, F., 1985. Biological factors in deterioration of paper. Roma, ICCROM.

GERRITSEN, J. KOETER, G. H., DEMONCHY, J. G. and KNOL, K., 1990. Allergy in subjects with asthma from childhood to adulthood. J. Allergy and Clin. Immunology, **85**, 116–125.

Institute Pasteur, 1976. Allergie. Paris.

KANTARCI, M. D., 1980. Belgrad Ormanı Toprak Tipleri ve Orman Yetişme Ortamı Birimlerinin Haritalanması Esasları Üzerine Araştırmalar (Untersuchungen über die Böden- und Standortkartierung im Belgrader Wald bei Istanbul). İstanbul Üniv. Orman Fak. Yayın. İ.Ü. Yayın No.2636, Orman Fak. Yayın No. 275, İstanbul.

MARTIN, J. P., 1950. Use of acid, rose bengal and streptomycin in the plate method for estimating soil fungi. Soil Sci., **69**, 215–233.

ÖZKARAGÖZ, K., 1969. A study of airborne fungi in the Ankara area of Turkey in 1966. Acta Allergol., **XXIV**, 147–156.

PASANEN, A. L., PASANEN, P., JANTUNEN, M. J. and KALLIOKOSKI, P., 1991. Significance of air humidity and air velocity for fungal spore release in the air. Atmos. Environ., **25A**, 459–462.

PEAT, J. K., TOVEY, E., MELLIS, C. M., LEEDER, S. R. and WOOLCOCK, A. J., 1993. Importance of house dust mite and *Alternaria* allergens in childhood asthma-an epidemiologic-study in two climatic regions of Australia. Clinical and Exper. Allergy, **23**, 812–820.

RAPER, K. B., THOM, C. and FENNEL, D. I., 1949. A Manual of the Penicillia. The Williams and Wilkins Comp., Baltimore, USA.

RAPER, K. B. and FENNEL, D. I., 1965. The Genus *Aspergillus*. The Williams and Wilkins Comp., Baltimore, USA.

RIFAI, M. A., 1969. A Revision of the Genus *Trichoderma*. Commonwealth Mycol. Inst. Mycological Papers, No.116.

ROSAS, I., CALDERON, C., ULLOA, M. and LACEY, C., 1993. Abundance of *Penicillium* CFU in relation to urbanization in Mexico city. Appl. Environ. Microbiol., **59**, 2648–2652.

SAVINO, E. and CARETTA, G., 1992. Airborne fungi in an Italian rice mill. Aerobiologia, **8**, 267–274.

SIMMONS, E. G., 1967. Typification of *Alternaria*, *Stemphylium* and *Ulocladium*. Mycologia, **59**, 67–91.

SMITH, G., 1971. An Introduction to Industrial Mycology. Sixth Edition. Edward Arnold Ltd., London.

WAKSMAN, S. A., 1944. Three decades with soil fungi. Soil Sci., **58**, 89–114.

ZYCHA, H. und SIEPMANN, R., 1969. Mucorales. Eine Beschreibung aller Gattungen und Arten dieser Pilzgruppe. Mit einem Beitrag zur Gattung *Mortierella* von G. LINNEMANN. Verlag von J. CRAMER, Lehre.

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