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STUDIES ON THE AEROMYCOSPORA OF DEHRA DUN CITY[1,2,3]

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ABSTRACT

Aeromycospora of Dehra Dun citywas studied for two years to record different allergens, pathogens and saprophytes. The culture plates and glycerine-jelly coated slides were exposed. Seasonal and diurnal periodicities of total spora and of major fungi were recorded. Different plant pathogens like *Alternaria*, *Drechslera*, rusts and smuts; human pathogens e. g. *Blastomyces* and allergens like *Aspergillus*, *Penicillium* and *Spicaria* were trapped. Total 142 types of fungi were observed by the exposures of culture plates and *Alternaria alternata* was found to contribute maximum. By exposing the glycerine-jelly coated slides, 25 spores types were recorded. *Alternaria* and round spores were highest contributors. The atmosphere of Dehra Dun city was found to harbour greater number of fungal species but in lesser concentration.

INTRODUCTION

Studies on aeromycology are highly significant due to their applications in forecasting of plant diseases, allergy, litter decomposition and allied aspects of microbiology. Saprophytic air-fungi are also reported to protect the plants from pathogens through defence by phytoalexins or by direct antagonistic reactions (Zadoks 1973). Seasonal and diurnal periodicities of different air-fungi have been investigated at a few cities in India (Ramalingam 1971; Bhati & Gaur 1979). The present survey was carried out in Dehra Dun city, India, to study the quantitative and qualitative aspects of different allergens, pathogens and saprophytes present in the atmosphere.

MATERIALS AND METHODS

Trapping site : Fungal trappings were done in Dehra Dun city, India. Dehra Dun lies 637 m above mean sea level and has an area of about 100 km². It is situated between 28° 30′ and 30°32′ north latitude or 77° 39′ and 78° 18′ east longitude. Dehra Dun has awide variety of vegetation and its climate is tropical mansoon type. In the centre of the city, a building with clear surroundings was chosen as trapping site. Near to the site are forests dominated by sal and fields of vegetables and seasonal crops like wheat, rice, sugarcane, pulses. Guava and litchi orchards are also present in nearby areas.

Trapping methods : (A) Exposures of

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culture plates (culture method) : The petri dishes (10 cm diameter) containing rose bengal agar culture medium were exposed horizontally to the atmosphere. The medium used differed from Martin's rose bengal streptomycin agar culture medium (Agarwal *et al.*, 1963). in that streptomycin was not added in the present medium. The dishes were exposed twice a week for 5 minutes at 6 m height from ground level. On each trapping day, one dish was exposed at 08.00 hours, another at 12.00 hours and third at 20.00 hours to observe the diurnal periodicity. The dishes were incubated at 28+1°C or about a week and fungal colonies developing therein were counted and identified.

(B) Exposures of glycerine-jelly coated slides (visual counting method) : A trapping device was fabricated on the lines of Durham's gravity sampler (Durham, 1946). Two aluminium discs (21 cm dia) were horizontally set 8 cm apart with 3 struts, and 2 slide holders were fixed at 2 cm above the lower disc. This sampler was nailed on the roof at a height of 8 m above the ground. Two slides coated with glycerine-jelly (Erdtman, 1952) were simultaneously exposed for a fortnight, and a cover slip was placed on each slide at the site itself to avoid contamination. Two quadrats of 25 mm^2 each were placed at random on each slide, and imprisioned fungal spores and hyphae were studied.

Trapping of the aeromycospora by both the methods mentioned above, were simultaneously done for two years (July 1978 to June 1980). For discussing the findings, the study has been divided into 1st year of study (July 1978 to June 1979) and 2nd year of study (July 1979 to June 1980). The meterological data was obtained from the observatory of the Forest Research Institute, Dehra Dun.

RESULTS AND DISCUSSION

By the culture method, total 142 types of fungi were observed in both the years of study (Table 1). Out of these, apart from yeasts, unidentified and ste-

TABLE I

SEASONAL VARIATIONS, PERCENTAGE CONTRIBUTIONS AND OTHER DATA OF DIFFERENT FUNGI DURING JULY 1978 TO JUNE 1980

Sl. No.	Type of fungi	Seasonal variation[1]		No. of days caught[2]	Total colonies		Percentage contribution	
		Period of occurrence	Peak period		July 1978 to June 1979	July 1979 to June 1980	July 1978 to June 1979	July 1979 to June 1980
1	2	3	4	5	6	7	8	9
1.	*Acremoniula sarcinellae*	11	—	1	—	1	—	0.05
2.	*Acremonium vitis*	10	—	1	—	1	—	0.05
3.	*Alternaria alternata*	1—12	1—6	198	330	377	17.96	20.35
4.	*A. brassicae*	11	—	1	1	—	0.05	—
5.	*A× brassicicola*	4, 6, 12	—	3	2	1	0.11	0.05
6.	*A. longipes*	2, 4, 9—10	—	4	1	3	0.05	0.16
7.	*A. longissima*	9	—	1	—	1	—	0.05
8.	*A. sesami*	5	—	1	1	—	0.05	—

TABLE I—(*Contd.*)

1	2	3	4	5	6	7	8	9
9.	*A. tenuissima*	1—5, 8—11	—	20	16	8	0.87	0.44
10.	*Aspergillus caespitosus*	11	—	1	—	1	—	0.05
11.	*A. candidus*	2,5, 10	—	7	3	4	0.16	0.22
12.	*A. fumigatus*	1—12	3, 5, 11—12	166	170	202	9.25	11.00
13.	*A. funiculosus*	1—12	1—2, 7, 10	147	148	152	8.06	8.28
14.	*A. humicola*	1—3 5—12	8—9	66	50	39	2.72	2.12
15.	*A. koningi*	1, 3, 9, 11	—	7	—	7	—	0.38
16.	*A. luchuensis*	4—6, 8—9 11	—	8	4	4	0.22	0.22
17.	*A. nidulans*	4—5 9—10	—	5	3	2	0.16	0.11
18.	*A. niger*	1—12	7	141	152	118	8.27	6.43
19.	*A. ochraceous*	5—6, 11	—	3	1	2	0.05	0.11
20.	*A. sulphureus*	4, 7	7	5	3	3	0.16	0.16
21.	*A. versicolor*	6, 10, 12	—	3	1	2	0.05	0.11
22.	*A. wentii*	7, 9	—	2	1	4	0.05	0.22
23.	*Aureobasidium* species	2, 11	—	3	—	4	—	0.22
24.	*A. pullulans*	1, 3, 5—7	—	7	3	6	0.16	0.32
25.	*Blastomyces* species	7	—	1	—	1	—	0.05
26.	*Botryotrichum* species	1—3, 8; 10	—	6	—	7	—	0.38
27.	*Botryotrichum* state of *Chaetomium piluliferum*	10—11	—	4	2	2	0.11	0.11
28.	*Botrytis bassiana*	12	—	1	1	—	0.05	—
29.	*B. pyramidalis*	9	—	1	—	1	—	0.05
30.	*Cephalosporium acremonium*	3 10	—	3	—	6	—	0.33
31.	*C. curtipes*	3, 6, 10	—	6	7	1	0.38	0.05
32.	*Cercospora* species	10	—	1	—	1	—	0.05
33.	*Chaetomella* species	2	—	1	—	1	—	0.05
34.	*Chaetomium* species	4—6, 10	—	7	2	5	0.11	0.27
35.	*Chaetophoma* species	5, 10	—	2	1	1	0.05	0.05
36.	*Cladosporium cladosporioides*	1—12	1—2, 10	130	139	117	7.57	6.37
37.	*C. cucumerinum*	10	—	1	—	1	—	0.05
38.	*C. mucsae*	6	—	1	1	—	0.05	—
39.	*C. oxysporum*	10	—	2	1	1	0.05	0.05
40.	*C. sphaerospermum*	1, 6, 12	—	4	1	4	0.05	0.22
41.	*Colletotrichum* species	7	—	3	3	—	—	0.16
42.	*Curvularia* species	11	—	1	—	1	—	0.05
43.	*C. affinis*	11	—	1	—	1	—	0.05
44.	*C. borreriae*	10	—	1	—	1	—	0.05
45.	*C. lunata*	1—12	8—9, 12	131	124	121	6.75	6.59
46.	*C. lunata* v. *aeria*	3, 6, 9—11	—	5	2	4	0.11	0.22

TABLE I—(*Contd.*)

1	2	3	4	5	6	7	8	9
47.	*C. oryzae*	4	—	1	—	1	—	0.05
48.	*C. pallescens*	1—12	9—11	150	185	138	10.07	7.52
49.	*Cylindrocephalum* species	6	—	1	—	1	—	0.05
50.	*Drechslera australiensis*	1—12	8—9	132	114	71	6.21	3.87
51.	*Drechslera* state of *Cochliobolus cynodontis*	6	—	1	1	—	0.05	—
52.	*Drechslera* state of *Cochliobolus miyabeanus*	8	—	1	—	1	—	0.05
53.	*Drechslera dematioidea*	11	—	1	—	1	—	0.05
54.	*Drechslera erythrospila*	9	—	1	—	1	—	0.05
55.	*D. frumentacei*	3, 9	—	2	1	1	0.05	0.05
56.	*D. hawaiiensis*	1, 3—6, 8—10	8	37	29	13	1.58	0.71
57.	*Epicoccum purpurascens*	1—4, 6, 9—10	—	9	3	6	0.16	0.33
58.	*Fumago* species	2—3, 5	—	3	—	3	—	0.16
59.	*Fusarium* species	1—12	—	66	40	33	2.18	1.80
60.	*F. chlamydosporum*	1	—	1	—	1	—	0.05
61.	*F. decemcellulare*	7	—	1	—	1	—	0.05
62.	*F. graminum*	1,3—4,7,9—12	—	21	10	11	0.54	0.60
63.	*F. lateritium*	4	—	1	1	—	0.05	—
64.	*F. lateritium* v. *minus*	1—2, 4—6, 10	—	13	11	2	0.60	0.11
65.	*F. merismoides*	9	—	1	1	—	0.05	—
66.	*F. moniliforme* v. *minus*	5—10	—	19	14	8	0.76	0.44
67.	*F. neoceras*	2,5—6,8,10,12	—	15	9	6	0.49	0.33
68.	*F. nivale*	1, 4—10	—	15	6	9	0.33	0.49
69.	*F. solani* v. *minus*	3	—	1	1	—	0.05	—
70.	*Fusidium* species	8, 10	—	2	—	2	—	0.11
71.	*Geotrichum* species	7—8	—	3	1	3	0.05	0.16
72.	*G. candidum*	5—6, 8	—	4	3	1	0.16	0.05
73.	*Gliocladium catenulatum*	7	—	1	—	1	—	0.05
74.	*G. roseum*	10	—	1	—	1	—	0.05
75.	*Gliomastix* species	6—7, 10	—	3	1	2	0.05	0.11
76.	*G. murorum*	2, 6	—	4	—	5	—	0.27
77.	*G. murorum* v. *felina*	10	—	1	—	1	—	0.05
78.	*Graphium bulbicola*	7	—	1	—	1	—	0.05
79.	*Gyrothrix* species	4	—	1	1	—	0.05	—
80.	*Hansfordia ovalispora*	5, 9	—	2	1	1	0.05	0.05
81.	*Haplosporangium* species	4, 6—7, 10, 12	—	8	4	4	0.22	0.22
82.	*Humicola brevis*	3, 11	—	2	1	1	0.05	0.05
83.	*Hgrisea*	9	—	1	—	1	—	0.05
84.	*Monilia* species	2, 6	—	3	—	3	—	0.16

TABLE I—(*Contd.*)

1	2	3	4	5	6	7	8	9
85.	*Monosporium* species	3	—	1	—	1	—	0.05
86.	*M. olivaceum* v. *major*	4	—	1	1	—	0.05	—
87.	*Mucor fragilis*	5—6, 8	—	3	2	1	0.11	0.05
88.	*M. globosus*	3, 6, 11	—	4	2	2	0.11	0.11
89.	*M. janssenii*	5	—	1	—	1	—	0.05
90.	*M. lausannensis*	4, 10, 12	—	3	—	3	—	0.16
91.	*M. petrinsularis*	9	—	1	—	1	—	0.05
92.	*Myrothecium advena*	11	—	1	—	1	—	0.05
93.	*M. roridum*	8	—	1	—	1	—	0.05
94.	*Nigrospora* state of *Khuskia oryzae*	2, 4-8—11	10	13	2	12	0.11	0.65
95.	*Nigrospora sacchari*	7	—	2	—	2	—	0.11
96.	*N. sphaerica*	5, 9	—	3	1	2	0.05	0.11
97.	*Oidiodendron* species	3, 5—9, 11	—	9	3	6	0.16	0.33
98.	*Penicillium* species	1, 4—5, 7, 11—12	11	15	11	6	0.60	0.33
99.	*P. atrovenetum*	10	—	1	—	1	—	0.05
100.	*P. canadense*	8, 10	—	2	—	2	—	0.11
101.	*P. chermesinum*	1—2, 5—6, 8—10	2, 8—9	20	15	6	0.82	0.33
102.	*P. citreo-viride*	3, 11	—	2	1	1	0.05	0.05
103.	*P. decumbens*	1—2, 4—9, 10, 12	—	29	9	21	0.49	1.53
104.	*P. herquei*	9—10	—	4	2	2	0.11	0.11
105.	*P. jenseni*	10	—	3	3	1	0.16	0.05
106.	*P. lansosum*	2, 6, 9, 12	—	8	6	3	0.33	0.16
107.	*P. pallidum*	9—10	—	3	—	3	—	0.16
108.	*P. vinaceum*	10	—	1	—	1	—	0.05
109.	*P. waksmani*	1, 3, 6—9	—	11	14	—	0.76	—
110.	*Phialophora* species	5—7	—	4	1	3	0.05	0.16
111.	*P. fastigiata*	10—11	—	2	—	2	—	0.11
112.	*Phoma glomerata*	6	—	1	—	1	—	0.05
113.	*P. hibernica*	2, 6, 11	—	6	4	2	0.22	0.11
114.	*P. humicola*	3	—	3	2	1	0.11	0.05
115.	*Rhizoctonia* species	2, 6—7, 12	—	6	—	6	—	0.33
116.	*Rhizopus nigricans*	1—12	1—2, 7—8, 12	47	24	28	1.31	1.53
117.	*R. oryzae*	1, 5-7, 10	—	6	4	2	0.22	0.11
118.	*Scopulariopsis brumptii*	2	—	1	—	1	—	0.05
119.	*Septonema* species	2	—	1	—	1	—	0.05
120.	*Spicaria divaricata*	1, 3, 5-6 11-12	1	14	6	10	0.33	0.54
121.	*Sporotrichum epigaeum* v. *terrestre*	6	—	1	1	—	0.05	—

TABLE I—(*Contd.*)

1	2	3	4	5	6	7	8	9
122.	*Stachybotrys atra*	2	—	2	—	2	—	0.11
123.	*S. parvispora*	5	—	1	1	—	0.05	—
124.	*Stemphylium* species	3,6	—	2	1	1	0.05	0.05
125.	*Stemphylium* state of *Pleospora herbarum*	5, 9	—	2	2	—	0.11	—
126.	*Streptomyces* species	6-7, 9, 12	—	4	2	3	0.11	0.16
127.	*Thielavia* species	7	—	1	1	—	0.05	—
128.	*Tilachildium* species	8	—	2	1	1	0.05	0.05
129.	*Torula graminis*	10	—	1	—	1	—	0.05
130.	*Trichoderma album*	2-3, 9-10	—	4	3	2	0.16	0.11
131.	*T. koningi*	6	—	2	1	2	0.05	0.11
132.	*T. lignorum*	4, 6	—	4	5	2	0.27	0.11
133.	*Trichothecium roseum*	3-4	—	2	—	2	—	0.11
134.	*Ulocladium* species	2	—	1	1	—	0.05	—
135.	*Verticillium* species	9	—	1	—	1	—	0.05
136.	*V. puniceum*	4	—	1	1	—	0.5	—
137.	Yeasts	3-4, 7, 9-11	—	6	2	5	0.11	0.27
138.	*Zygodesumus* species	12	—	1	—	1	—	0.05
139.	Unidentified	1-2, 5-10	—	14	9	5	0.49	0.27
140.	Black sterile	1-12	—	65	32	35	1.74	1.91
141.	Orange sterile	2	—	1	—	1	—	0.05
142.	White sterile	1-12	1-2, 7	105	52	71	2.83	3.87

1. Indicated by numbers corresponding with the months of year.
2. Out of 214 trapping days in both the years of stduy.

rile fungi, species of 56 genera belonging to Phycomycetes, Ascomycetes and Deuteromycetes were observed. Qualitatively thus, the present study reports greater number of fungal types than recorded from other places (Tilak & Bhalke 1978; Bhati & Gaur 1979), due to the variety of vegetation found in Dhera Dun. Different crops in the valley and forest vegetation in the surroundings make its atmosphere unique in composition. Although every locality represents its own aerobiota, in the present study, a number of fungi e. g. *Alternaria, Aspergillus, Cladosporium, Fusarium* and *Penicillium* etc. are of common occurrence and have been reported from many parts of the world. *Aureobasidium, Botryotrichum, Haplosporangium, Oidiodendron, Spicaria* and yeasts appear to be comparatively common to Dehra Dun atmosphere than that of other places. Spp. of *Aspergillus, Penicillium* and *Spicaria* reported to be aeroallergens (Solomon,1969; Rati, Jayaprakash & Ramalingam, 1980) were trapped. *Aspergillus fumigatus* which causes pulmonary aspergillosis (Frankland, 1977), and *Blastomyces* which causes blastomycosis were human pathogens recorded in the present study.

By exposing the glucerine-jelly coated slides (visual counting method) 25 spore types were recorded (Table II). These types belong to Phycomycetes,

TABLE II

SEASONAL VARIATIONS, PERCENTAGE CONTRIBUTIONS AND OTHER DATA OF DIFFERENT SPORE TYPES DURING JULY 1978 TO JUNE 1980

Sl. No.	Spore type	Seasonal variation[1]		quad-	No. of Total spores		Percentage contribution	
		Period of occurrence	Peak period	rates in which + trapped[2]	July 1978 to June 1979	July 1978 to June 1980	July 1978 to June 1979	July 1978 to June 1980
1.	*Alternaria*	1-12	3-6	160	186	263	25.55	40.40
2.	*Bispora*	1	—	1	—	1	—	0.15
3.	*Ceratophorum*	9	—	1	—	1	—	0.15
4.	*Cercospora*	5	—	1		1	—	0.15
5.	*Cladosporium*	1, 7-9, 11-12	—	11	10	4	1.37	0.61
6.	*Curvularia*	1-3, 5-12	10	64	61	83	8.38	12.75
7.	*Dictyosporium*	10	—	1	1	—	0.14	—
8.	*Diplosporium*	8-9	—	2	—	2	—	0.31
9.	*Drechslera*	1-12	9, 11	95	97	59	13.32	9.06
10.	*Epicoccum*	1—5, 7,10	3—4	24	12	18	1.65	2.76
11.	*Fusarium*	1—2, 7—12	10	11	14	3	1.92	0.46
12.	*Helminthosporium*	1	—	1	—	1	—	0.15
13.	*Memnoniella*	2, 7, 11	—	3	1	2	0.14	0.31
14.	*Nigrospora*	3, 5	—	2	3	—	0.41	—
15.	*Peironia*	4	—	1	1	—	0.14	—
16.	*Pestalotia*	8—9	—	3	1	2	0.14	0.31
17.	*Pithomyces*	10	—	1	1	—	0.14	—
18.	*Septonema*	8	—	2	—	2	—	0.31
19.	*Stemphylium*	1—9, 11—12	—	26	14	33	1.92	5.07
20.	*Tetraploa*	9—10	—	2	—	2	—	0.31
21.	Round spores	1—12	1, 7—11	114	241	87	33.10	13.36
22.	Hyphal fragments	1—12	—	100	60	61	8.24	9.37
23.	Rust spores	3—5, 10—12	3—5	13	9	13	1.24	2.00
24.	Smut spores	3—5, 11	3	8	5	5	0.69	0.77
25.	Unidentified	2—9, 11—12	—	19	11	8	1.51	1.23

[1]Indicated by numbers corresponding with the months of year.
[2]Out of 192 quadrats studied in both the years of study.

Ascomycetes, Basidiomycetes and Deuteromycetes. Round or almost round spores were categorized under 'round spores and in this category fall the spores of fleshy fungi, molds and conidia of powdery mildews etc. Hyphal fragments and unidentified spores were also categorized separately. Higher numbers of spore types have been reported by Tilak & Bhalke (1978) and Bhati & Gaur (1979) as larger areas of sticky material were scanned.

From the total exposures of 642 culture plates, 3673 fungal colonies and of 96 glycerine-jelly coated slides, 1379 spores were recorded in two years. Bhati & Gaur (1979) observed 7278 colonies from exposing 342 culture plates (8 cm diam.) and 37395 spores from 365 slides at Modinagar, while Ramalingam (1971) trapped 9759 colonies from 21 plates (diam. not reported). Quantitatively thus the atmosphere of Dehra Dun harboured lesser number of biopollutants which shows that it has comparatively 'clean' atmosphere.

Major constituents : By the culture method, *Alternaria alternata* was found to constitute maximum—17.96% in the 1st year (July 1978 to June 1979) and 20.53% in the 2nd year of study (July 1979 to June 1980). *Alternaria* was also observed to contribute highest at Jaipur (Gupta, Sogani & Kasliwal, 1960), Phoenix, Arizona (Goodman *et al.*, 1966) and Lucknow (Vishnu-Mittre & Khandelwal, 1973), but it was however not identified upto specific level in these studies. In the present study, *A. alternata* was followed by *Curvularia pallescens* in the 1st year and *Aspergillus fumigatus* in the 2nd year of study (Table 1). By the visual counting method, *Alternaria* also contributed maximum in the 2nd year of study and followed by round spores (Table II). In the 1st year, however, highest contribution was made by round spores and *Alternaria* followed it.

Seasonal periodicity of total aeromycospora and effect of different factors : The year has been divided into 3 seasons—rainy (July to October), winter (November to February) and summer (March to June). By the culture method, rainy season was found to contribute highest, followed by summer, and by the visual counting method, summer was observed to constitute maximum followed by rainy season in both the years of study (Table III). This difference may be attributed to the rains which largely affected the trappings by the visual counting method because they leave the atmosphere 'clean' for a long duration. But the rains affected the recordings by the culture method only when they occurred just before the timings of trappings. When they occurred after the trappings, there was no or little effect on the findings. Minimum spora by both the methods was found in winter in both the years of study due to unfavourable low temperature (Fig. 1). Ramalingam (1971) and Bhati & Gaur (1979) however observed minimum spora in summer in plains of India.

Seasonal periodicity of aeromycospora is related with the vegetation, organic dead contents and weather conditions like temperature, wind velocity, relative humidity and rainfall. The periodicity of total spora have been presented in Figs. 2 & 4. High temperature, heavy rainfall, low wind velocity and low relative humidity reduced the spora concentration. Rise in spora was observed in spring and autumn seasons.

Seasonal variations of different fungi : By the culture method, a number of fungal types were recorded to be abundant in different seasons and a few were in almost uniform concentration throughout the year (Figs. 3A & B). Thus,

TABLE III

TOTAL SPORA AND PERCENTAGE CONTRIBUTIONS IN DIFFERENT SEASONS AS DETERMINED BY THE CULTURE AND VISUAL COUNTING METHODS

Season	Culture method				Visual counting method			
	July 1978 to June 1979		July 1979 to June 1980		July 1978 to June 1979		July 1979 to June 1980	
	Total colonies	P. C.	Total colonies	P. C.	Total spores	P. C.	Total spores	P. C.
Rainy	694	37.78	742	40.41	242	33.24	237	36.41
Winter	495	26.95	503	27.67	223	30.63	156	23.96
Summer	64	35.27	586	31.92	263	36.13	258	39.63
Total	1837		1836		728		651	

P. C.—Percentage contribution.

following 4 categories can be made out:

(a) Fungi abundant in rainy season–*Aspergillus humicola, Curvularia lunata, C. pallescens, Drechslera australiensis, D. haawiiensis, Nigrospora* state of *Khuskia oryzae* and *Penicillium chermesinum*

(b) Fungi abundant in winter season—*Aspergillus fumigatus, Penicillium* spp. and *Spicaria divaricata*

(c) Fungi abundant in summer season—*Alternaria alternata*; *Alternaria* has also been found to be in maximum concentration in the months of summer at Jaipur (Gupta, Sogani & Kasliwal, 1960) and at Lucknow (Vishnu-Mittre & Khandelwal, 1973)

(d) In uniform concentration throughout the year—*Aspergillus funicolosus, A. niger, Fusarium* spp., white and black sterile colonies.

Cladosporium cladosporioides and *Rhizopus nigricans* were abundant in both the rainy and winter seasons (Fig. 3). Although the fungi discussed above showed variations with respect to different seasons but *Alternaria, Aspergillus, Cladosporium, Curvularia, Drechslera, Fusarium, Penicillium* and *Rhizopus* were encountered throughout the year due to their wide range of adaptability on variety of the vegetation, debris and in different weather conditions prevailing in this city. A number of other fungi due to their sporadic occurrences, could not be classified in the above categories.

The monthly variations of a few frequently trapped spore types as observed by the visual counting method, are presented in Fig. 2. *Alternaria* was recorded to be abundant in summer and this is in conformity with the findings made by the culture method. *Epicoccum*, rust and smut spores were also in high concentrations in summer. Grasses including wheat favoured rusts and smuts in summer. *Epicoccum* has also been recorded in high concentration in March-April at Mysore (Ramalingam, 1971). *Curvularia* was abundant in rainy season corroborating the results taken by culture method. Round spores were also frequently trapped in rainy season and the same were the observations of Ramalingam (1971). Hyphal fragments

Fig. 1 Weather at Dehra Dun in 1979 and 1980

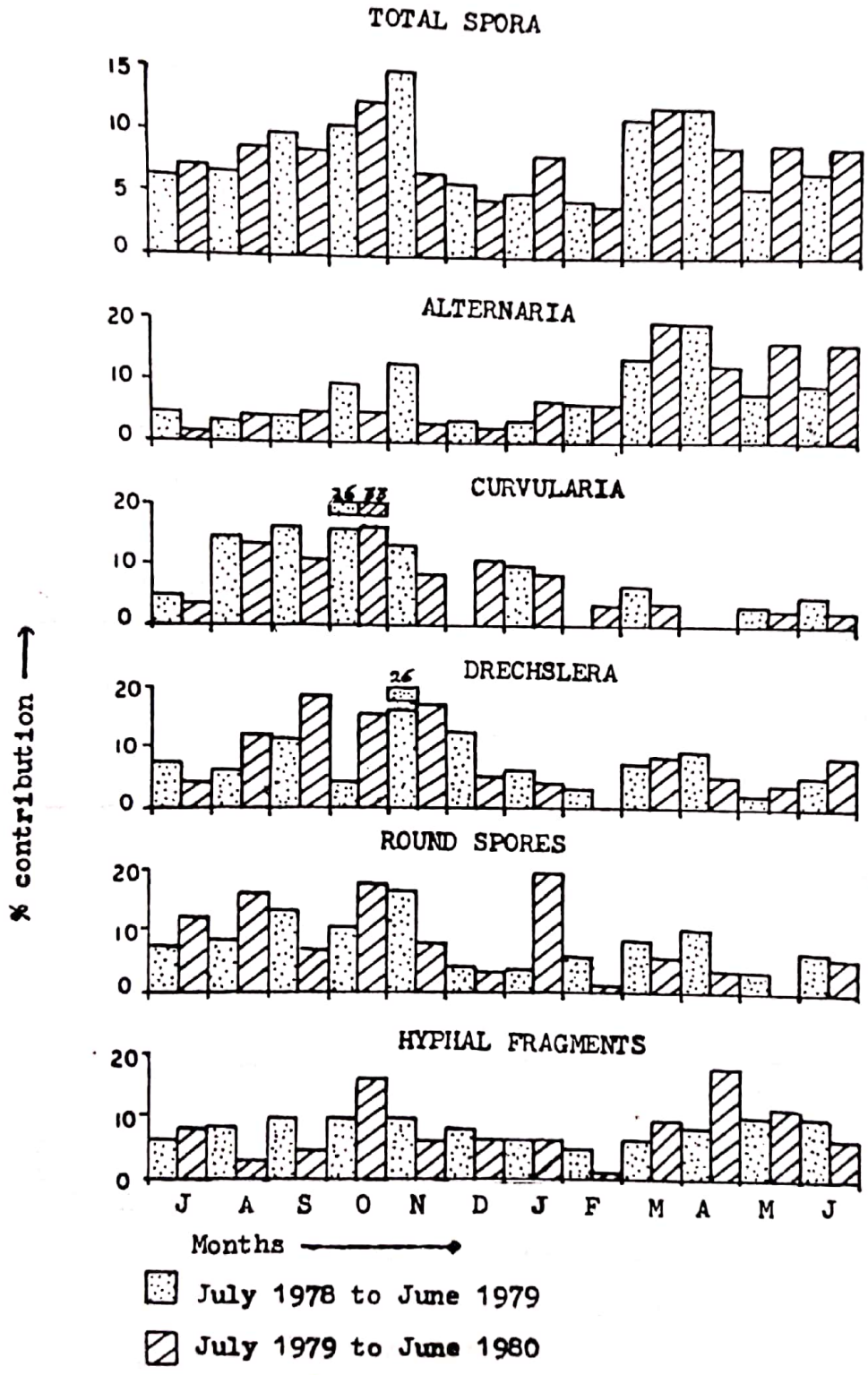

Fig. 2. Seasonal periodicities of total spora and of major opore types as determined by the visual counting method

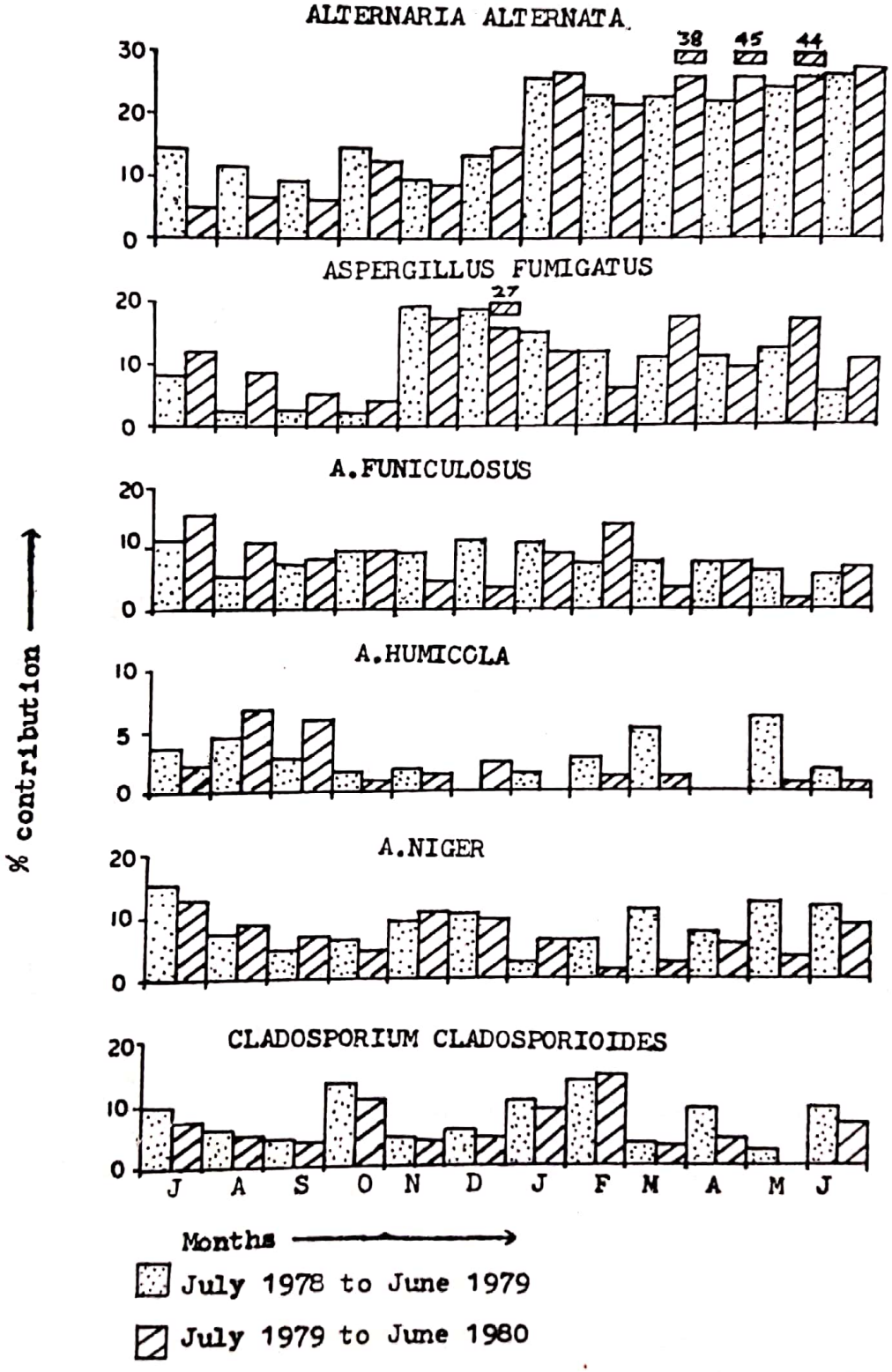

Fig. 3A. Seasonal periodicity of total spora and of major fungi as determined by the culture method

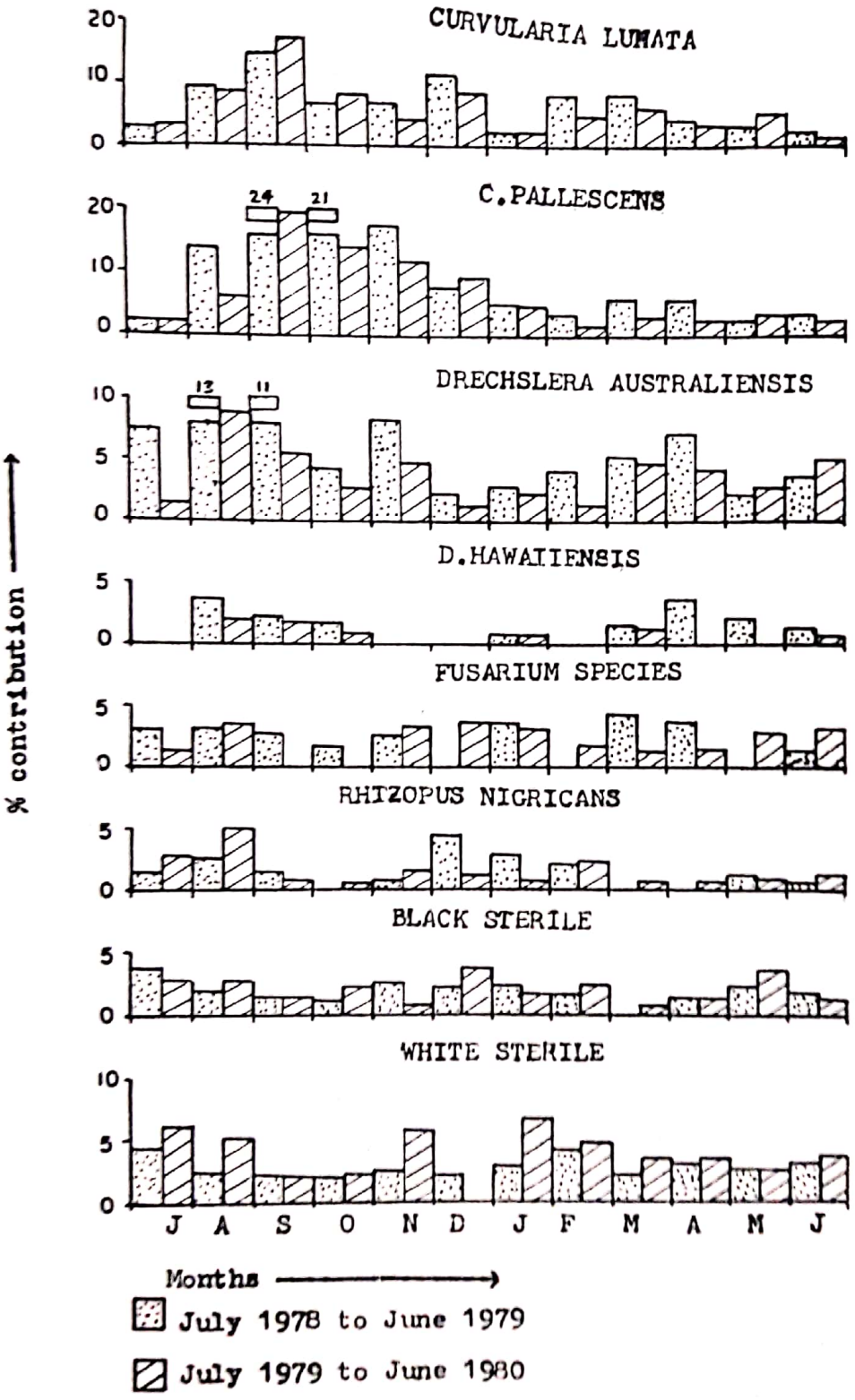

Fig. 3B. Seasonal periodicity of total spora and of major fungi as determined by the culture method

Fig. 4. Monthly diurnal variations of total spora

were almost uniformly trapped throughout the year. The seasonal variations of other types could not be assessed due to their sporadic trappings

Diurnal periodicity : Diurnal periodicities of total spora and of different fungi were determined by the culture method only. Total aeromycospora was observed to be low at 08.00 hours, rising to maximum at 12.00 hrs. and then again relatively low at 20.00 hrs. (Fig. 4). This periodicity may be due to following reasons—(a) Wind moves faster at noon because of more expansion at that time thus blowing much more spores and consequently helping in the raised spora concentration in air at 12.00 hrs. (b) In early morning, the spores remain arrested in dew drops etc. and as the day breaks, rise in temperature dries the drops and water films etc. to release the spores. The wind gets the opportunity to lift them up thereby increasing the spora at 12.00 hrs. Gregory (1961) has reported that during the morning hours, rapid changes in atmospheric humidity occur resulting in the hygroscopic movements of conidiophores leading to the detachment of spores. The latter become 'available' in forenoon hours. (c) In the trappings at 20.00 hrs., the spora was low due to settlement of a number of spores, and non-sporulation just before this time.

Above generalization may not be true to all the fungi. Different fungi showed their peak concentrations at different timings—(a) Peak around 08.00 hrs.—*Alternaria tenuissima, Aspergillus funiculosus* and *Penicillium decumbens*. (b) Peak around 12.00 hrs.—*Alternaria alternata, Curvularia lunata, C. pallescens* and black sterile colonies. Mishra (1972) also observed in Gorakhpur that *Alternaria* was in high frequency at 13.00 hrs. due to comparatively dry air at that time facilitating the discharge of spores. (c) Peak around 20.00 hrs.—*Cladosporium cladosporioides, Fusarium* spp., *Spicaria divaricata* and white sterile colonies. Pady, Kramer & Willey (1962) also categorized *Fusarium* in night spora, and reported that it was due to the low temperature and high humidity. (d) Without definite peak time—*Aspergillus fumigatus, A. humicola, A. niger, Drechslera australiensis D. hawaiiensis, Fusarum graminum, Penicillium* spp. and *Rhizopus nigricans*. Tilak & Kulkarni (1975), however, reported *Rhizopus* exhibiting peak-hours in forenoon at Aurangabad.

A number of other fungi were not frequently recorded. Therefore, their diurnal periodicities could not be determined.

The combination of culture and visual counting methods for studying aeromycospora have been found to comp-

lement the findings of each other. Atmosphere of Dehra Dun was found to be rich in the variety of fungi but harboured them in comparatively lower quantity. The quanta and periodicities of various fungi can be useful in allergology and forecasting of plant diseases.

REFERENCES

AGARWAL, M. K., D. N. SHIVPURI AND K. G. MUKERJI 1969. Studies on the allergenic fungal spores of the Delhi, India, metropolitan area. *J. Allergy* **44** : 193-203.

BHATI, H. S. AND R. D. GAUR 1979. Studies on aerobiology—atmospheric fungal spores. *New Phytol.* **82** : 519-527.

DURHAM, O. 1946. The volumetric incidence of atmospheric allergens. IV. A propose standard method of gravity sampling, counting and volumetric interpolation of results. *J. Allergy* **17** : 79-86.

ERDTMAN, G. 1952. *Pollen morphology and plant taxonomy : angiosperms*. Hafner Publishing Company, Stockholm.

FRANKLAND, A. W. 1977. *Aspergillus fumigatus* : a pathogen and allergen. *Grana* **16** : 181-182.

GOODMAN, D. H., W. T. NORTHEY, C. R. LEATHERS AND T. H. SAVAGE 1966. A study of air borne fungi in the Phoenix, Arizona, metropolitan area. *J. Allergy* **38** : 56-62.

GREGORY, P. H. 1961. *The microbiology of the atmosphere*. Leonard Hill (Books) Limited, London.

GUPTA, K. D., I. C. SOGANI AND R. M. KASLIWAL 1960. Survey of the allergenic mold spores at Jaipur. *Indian J. Chest Dis.* **2** : 237-241.

MISHRA, R. R. 1972. Aeromycology of Gorakhpur. IV. Periodical fluctuation of aerospora. *Mycopath. et Mycol. applic.* **48** : 213-222.

PADY, S. M., C. L. KRAMER AND B. J. WILLEY 1962. Kansas aeromycology. XII. Materials, methods and general results of diurnal studies 1959-1960. *Mycologia* **54** : 168-180.

RAMALINGAM, A. 1971. Air-spora of Mysore. *Proc. Indian Acad. Sci.* **74** : 227-240.

RATI, E., K. B. JAYAPRAKASH AND A. RAMALINGAM 1980. Air-spora of a poultry shed at Mysore. *Indian J. Microbiol.* **20** : 6-12.

SOLOMAN, W. R. 1969. Aeroallergens and Public Health. In : *Advances in Environmental Sciences and Technology* (ed. J. N. Pitts, Jr. & R. L. Metcalf), pp. 197-236. Wiley-Interscience, New, York.

TILAK, S. T. AND S. P. BHALKE 1978. Aeromycology of Aurangabad-II: Deuteromycetes. *Indian J. Bot.* **1** : 113-115.

TILAK, S. T. AND R. L. KULKARNI 1975. Atmospheric concentration of *Rhizopus* spores. *Biovigyanam* **1** : 91-94.

VISHNU-MITTRE AND A. KHANDELWAL 1973. Airborne pollen grains and fungal spores at Lucknow during 1969-70. *Palaeobotanist* **22** : 177-185.

ZADOKS, J. C. 1973. The role of epidemiology in modern phytopathology. *Phytopathology* **63** : 918-923.