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A COMPARATIVE SURVEY
OF ATMOSPHERIC POLLEN AND FUNGUS
SPORES AT TWO
PLACES TWENTY MILES APART

By

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INTRODUCTION

From the results of the extensive aerobiological surveys conducted in the U. K. and the U. S. A. by workers interested in studies on respiratory allergy, dissemination of plant pathogens and quaternary palynology, it is clear that the patterns in the incidence of air-borne allergens differ considerably from place to place and season to season. In their intensive studies, *Richards* (1956), *Hamilton* (1959), *Lacey* (1962) and *Davies* (1963) in England and *Gordon* (1957) in America have provided ample information indicating the influence of locality on the variations in pollen and spore content of the atmosphere which are of interest from an allergological point of view. Although the problem of allergy due to air-borne pollen and fungus spores was extensively studied in the West, it remained a neglected field in India. In the aerobiological work carried out so far in India (reviewed by *Sreeramulu* 1967) though there were some attempts to study the allergen distribution in the air and their clinical significance in North India, in South India no such attempt was made from the medical point of view except for some information provided on the components of the air-spores (*Sreeramulu & Ramalingam*

1966) and atmospheric pollen (*Ramalingam* 1966) over paddy fields near Visakhapatnam and a preliminary report on the air-spora of Vellore (*Nair* 1963).

With a view to make a comparative study of the major components of the air-spora at two different places in a year, a daily census was made from April 1966 till March 1967 at Visakhapatnam and Anakapalle, the results of which are presented here along with comparison of the data obtained in two consecutive years (1966-'67 and 1967-'68) at Visakhapatnam which are twenty miles apart.

METHODS

In any aerobiological work, the apparatus employed to catch the air-borne particles is important as each has its own virtues and limitations (*Gregory* 1961). Though the Hirst trap was found to be ideal for conducting aerobiological surveys, it too has its own limitations such as its non-portability and requirement of source of power to drive the suction pump for sucking air into the trap. Basing on field studies and wind tunnel work, *Gregory* (1951) found that the use of vertical cylinders (0.53 cm dia.) exposed in shelters of the Durham type yield equally valuable results and recommended their use in conducting routine aerobiological surveys.

In view of this, in the present study vertical glass cylinders of approximately 0.53 cm diameter (with 18 sq mm cellophane paper dipped in molten vaseline wound round the cylinder, used as the trapping surface) were exposed for 24-hour periods in the Durham type shelters of the size employed by *Hyde & Williams* (1945). After exposure the sticky cellophane paper on the cylinder with the day's catch was mounted in glycerine jelly and covered with a 22 mm square cover glass. Scanning was done by taking 18 counts at 1 mm apart under the high power objective (in a total area of 0.46 sq cm) and the counts were converted to number per square centimeter.

Some slides exposed in the Hirst spore trap operated at a height of 19 ft. a.g.l. in a sugarcane plot at the Sugarcane Research Station, Anakapalle were selected and scanned at hourly intervals with the high power objective under a scanning width of 310μ to gather information on the diurnal periodicities of certain Indian pollen types.

Identification of the pollen types was mainly based on the reference slides prepared (following the method of *Wodehouse* 1935) during the course of this study and where necessary books on palynology were consulted (*Wodehouse* 1935, *Erdtman* 1952, *Hyde & Adams* 1958).

SITES, SURROUNDINGS AND WEATHER

The two stations—Anakapalle, representative of rural area and Visakhapatnam, representative of urban area—are situated twenty miles apart. The trap at Anakapalle was placed on the roof of the Chemistry building (20 ft. a.g.l.) in the Sugarcane Research Station, the extent of which is 103 acres under cultivation of Sugarcane alternating with crops like *oryza*, *pennisetum*, *sorghum*, *eleusine* etc. Frequent agronomic practices like weeding disturbs the weed population. Numerous *Cocos* and *Borassus* trees are present in the vicinity.

The trap at Visakhapatnam was installed on the roof of the Erskine College building (30 ft. a.g.l.) on the University campus. The surroundings are occupied by huge buildings. On the western side there is the botanical garden and dense vegetation comprising of large trees like *Anacardium*, *Syzygium*, *Pongamia*, *Pterocarpus*, *Casuarina*, *Peltophorum* etc. Plenty of dead and decaying vegetable matter will be accumulating throughout the year. On the North-Eastern side about one mile away there is some cultivable land with *Pennisetum* crop grown in the season.

An amount of 1197.2 mm rain with 90 rainy days at Anakapalle and 1030.5 mm rain with 106 rainy days at Visakhapatnam was recorded during 1966-'67. During 1967-'68 at Visakhapatnam, a total of 712.28 mm rain with 88 rainy days was recorded.

RESULTS

Composition of the Catches and the Seasonal Changes in the Pollen and Spore Contents of the Air

In general all the pollen and fungus spore types occurring in the air at Anakapalle and Visakhapatnam in the periods of the present study exhibited distinct seasonal periodicities in their annual incidence though considerable fluctuations in their day to day incidence were noticed.

Daily averages in each month for the various kinds of pollen identified in the catches are given in Table 1 to indicate their monthwise distributions. The results of an analysis of the composition of the various groups in the total pollen catch are presented in Table 3. Day to day details of the atmospheric incidence of ten pollen types at the two sites in the year 1966-'67 are presented graphically in Figs. 1 and 2 where the extent of the season, the daily mean count and the estimated seasonal incidence for each of these types are included (for example $360 \times 103 = 37080$ given for grass in Fig. 1

TABLE 1
Daily Average Number (per 10 sq. cm of the Trap Surface) in Each Month.
Pollen Grains

Pollen type	A	M	J	J	A	S	O	N	D	J	F	M	Total
Grass	A 74 V 42 V* 64	26 13 23	154 27 12	8347 343 118	2428 585 1400	230 131 169	680 130 148	520 161 106	39 97 25	333 61 48	81 31 16	113 20 31	13025 1641 2160
Cyperaceae	A 2 V — V* 21	3 1 21	12 40 5	30 23 44	76 130 238	75 70 94	15 20 38	2 37 15	5 33 1	3 16 6	— 4 1	2 — 1	225 374 485
Amaranthus- Chenopod	A 11 V 5 V* 9	4 6 5	1 29 4	12 5 2	13 15 35	14 46 64	8 22 14	2 5 8	2 3 —	5 6 —	5 2 2	7 2 2	84 146 145
Compositae	A — V 1 V* 3	1 — 2	1 — —	— — —	5 5 1	— 3 1	7 1 2	1 1 2	1 2 5	3 1 2	2 4 6	1 4 1	22 22 25
Artemisia	A — V — V* —	— — —	— — —	— — —	— — —	— 3 4	2 10 21	— — 5	— — —	— — —	— — —	— — —	2 13 30
Xanthium	A — V — V* —	— — —	— — —	— — —	— — —	— — —	1 3 4	— — 3	— — 1	— — —	5 — —	8 1 —	14 4 12

TABLE I (cont.)

Pollen type	A	M	J	J	A	S	O	N	D	J	F	M	Total
Croton	A	-	1	3	3	-	-	-	-	-	-	-	7
	V	-	1	4	4	8	3	1	-	-	-	1	22
	V*	2	1	3	5	1	1	-	-	1	-	1	16
Acanthaceae	A	-	-	-	1	-	-	-	-	-	-	2	3
	V	-	-	-	3	-	-	-	5	1	-	-	9
	V*	1	6	-	3	3	-	1	-	-	-	-	14
Acalypha	A	-	-	-	4	-	-	-	-	-	-	-	4
	V	-	-	-	8	-	-	-	-	-	-	-	8
	V*	-	-	-	-	-	-	-	-	-	-	-	-
Casuarina	A	6	2	-	43	4	3	11	1	196	707	33	1010
	V	23	10	3	284	50	15	17	2	50	1186	119	1791
	V*	11	3	23	17	87	32	1	-	21	550	64	810
Borassus	A	296	63	4	4	-	-	-	-	-	2	46	415
	V	85	19	2	1	1	3	1	-	-	-	14	126
	V*	75	24	4	-	1	1	1	-	-	1	3	109
Cocos	A	39	19	4	14	7	9	3	1	1	8	19	125
	V	9	3	10	1	2	1	2	3	2	-	1	34
	V*	3	3	3	1	2	27	-	4	1	-	2	46
Phoenix	A	-	-	-	-	-	-	-	-	7	21	-	28
	V	-	-	-	-	-	-	-	2	10	361	71	444
	V*	-	-	-	-	-	-	-	-	61	19	37	117

TABLE 1 (cont.)

Pollen type	A	M	J	J	A	S	O	N	D	J	F	M	Total
Dodonaea													
A	-	-	-	-	-	-	-	-	209	86	-	-	295
V	-	-	-	-	-	-	-	27	619	28	-	-	674
V*	-	-	-	-	-	-	-	14	73	-	-	-	87
Ricinus													
A	3	-	-	-	5	-	12	-	-	-	-	-	20
V	-	-	-	1	3	-	10	13	-	-	7	4	38
V*	21	1	-	1	28	1	1	-	1	6	5	1	66
Morus													
A	-	-	-	-	5	1	-	1	-	-	15	3	25
V	2	1	2	1	5	3	1	1	-	-	1	2	19
V*	11	6	9	2	4	-	8	-	3	-	2	9	54
Holoptelea													
A	-	-	-	-	-	-	-	-	-	-	1	1	2
V	1	1	-	-	-	-	-	-	-	-	-	2	4
V*	2	-	-	-	-	-	-	-	-	-	2	7	11
Syzygium													
A	-	6	115	3	-	-	-	-	-	-	-	-	124
V	-	197	1697	34	5	-	-	-	-	-	-	-	1933
V*	5	64	877	22	28	-	-	-	-	-	-	-	996
Phyllanthus													
A	20	12	-	-	-	-	-	-	-	-	-	20	52
V	81	25	-	-	-	-	-	-	-	-	-	11	117
V*	96	10	-	-	-	-	-	-	-	-	1	19	126
Emblica													
A	-	-	-	-	-	-	3	-	-	-	-	-	3
V	-	-	-	3	3	6	-	1	2	-	-	3	18
V*	2	-	1	12	-	2	1	-	-	-	16	-	34

TABLE 1 (cont.)

Pollen type	A	M	J	J	A	S	O	N	D	J	F	M	Total
Prosopis	A	-	-	-	-	-	1	-	-	-	29	4	34
	V	-	-	-	-	-	-	-	-	-	-	-	-
	V*	-	-	-	2	-	-	-	3	2	-	-	7
Mimosoideae	A	-	1	1	3	2	-	-	-	-	-	-	7
	V	1	2	5	-	1	1	-	-	-	-	-	10
	V*	-	1	-	1	2	1	1	-	-	-	1	14
Leguminosae	A	7	1	1	-	-	-	-	-	-	-	-	9
	V	-	-	2	1	-	-	-	-	-	-	-	3
	V*	3	-	-	-	-	2	-	-	2	1	-	8
Myrtaceae (Eucalyptus)	A	-	-	-	2	1	-	-	-	-	-	-	3
	V	-	-	-	1	1	-	1	1	-	-	1	5
	V*	-	-	-	-	4	-	-	-	1	-	-	5
Ancardium	V	8	-	-	-	-	-	-	-	-	-	7	15
	V*	1	2	-	-	-	-	-	-	-	1	5	9
Bassia	V	49	1	1	-	-	-	-	-	-	1	5	57
	V*	14	1	-	-	-	-	-	-	-	-	16	31
Tamarindus	V	-	-	11	1	-	-	-	-	-	-	-	12
	V*	-	-	1	5	1	-	-	-	-	-	-	7
Muntingia	V	9	5	80	3	1	3	-	-	-	-	1	105
	V*	1	6	-	-	7	1	-	-	1	14	-	30

TABLE I (cont.)

Pollen type	A	M	J	J	A	S	O	N	D	J	F	M	Total
Peltophorum	V 2	-	45	84	1	2	-	-	-	-	-	2	136
	V* 32	28	17	3	7	6	1	-	-	-	-	-	94
Pongamia—	V 39	63	38	1	-	-	-	-	-	-	-	8	149
Pterocarpus type	V* 48	70	6	39	15	-	-	-	-	-	-	-	178
Millingtonia	V -	-	-	-	-	-	-	1	-	-	-	-	1
	V* -	-	-	-	-	-	-	3	1	-	-	-	4
Lythraceae	V -	-	-	-	2	1	-	-	-	-	-	-	3
(Lawsonia)	V* -	-	-	-	2	-	15	-	-	-	-	-	17
Total pollen	A 539	172	313	8419	2793	352	757	574	325	544	1000	306	16094
	V 414	411	2022	542	1085	361	264	296	786	210	1625	251	8267
	V* 608	308	911	316	1830	477	328	177	128	157	634	31	5905
<i>Fungus Spores</i>													
Total spores	A 1263	2687	2159	1656	2809	1543	1874	2168	2088	4154	4251	6970	33622
	V 772	3048	1501	1925	1737	1900	2452	4580	2380	6310	1059	1321	29012
	V* 1054	1591	1530	750	1254	1886	1739	1308	2920	1055	706	713	16506

A = Anakapalle, 1966-'67.

V = Visakhapatnam, 1966-'67.

V* = Visakhapatnam, 1967-'68.

represent that the grass pollen season extended over 360 days with a daily mean count of 103, and 37080 as the estimated seasonal incidence corrected to the nearest number).

Both at Anakapalle and Visakhapatnam the tree pollen season virtually started by January with the flowering of *Casuarina* and *Phoenix* and ended by June with *Syzygium*. *Casuarina* pollen was encountered all through the year though not on every day with a main peak in February and a subsidiary one in August-September. This type was remarkable for the long duration of its season. *Phoenix* pollen was caught in the period January-March with peak incidence in February. *Borassus* pollen though occurred occasionally in all the months, appeared along with *Phyllanthus* from March with higher numbers in April and then decreased to a minimum by May. *Syzygium* pollen was present from May till the middle of July with greater incidence in June. *Dodonaea* was prevalent in December. Pollen of *Cocos*, *Morus*, *Ricinus*, *Embllica* and *Mimosoideae* occurred either in low or high numbers all through the year and that of *Holoptelea* from February to May. In addition at Visakhapatnam *Bassia* pollen during March-May and *Anacardium* pollen in March-April, *Tamarindus* pollen in June-July were recorded. During the period March to September greater numbers of *Peltophorum* in April-June and *Pongamia-Pterocarpus* type in April-May were encountered. Other tree pollen types were from *Muntingia*, *Cochlospermum* at Visakhapatnam, *Polyalthia* and *Azadirachta* at Anakapalle.

Though wide fluctuations were observed in the grass pollen incidence, the season practically started with monsoon rains and the greatest density was noticed in the period July-August.

Among the weed pollen caught, Cyperaceous and Amaranthus-Chenopod type preponderated the catches with their respective peaks in August and September. *Artemisia* pollen was caught in September-October. Few grains of *Xanthium* were recorded in October and February. Crotonoid type was encountered on some days in different months. Other weed

pollen include the entomophilous Compositae, Acanthaceae and *Acalypha*.

The type of frequency diagrams exhibited by *Syzygium*, *Phyllanthus*, *Borassus*, *Casuarina*, *Dodonaea*, *Phoenix*, *Cyperaceae*, grass and *Amaranthus*-*Chenopod* type showed a compact pattern of alternate rises and falls, in which rises increase up to a maximum toward the middle of the season and thereafter decrease in contrast to that of *Cocos* in which there is no single obvious maximum phase. The former come under the category of *compact type* and the later under the *diffuse type* of the two types recognised by Hyde (1950).

Of the forty one categories of fungus spore types for which separate counts were taken, the details of the atmospheric distribution along with the annual incidence for twenty types are given in Fig. 3 where the daily averages in each month are plotted as histograms. For the other twenty one types data on the annual incidence and their percentage contributions to the total fungus air-spores are given in Table 2. The fungus spores were trapped either in low or high numbers all the year round at both Anakapalle and Visakhapatnam. *Cladosporium*, the preponderating type at both the places was encountered in significant numbers in all months with its seasonal maximum occurring in the period November–January. Among the other predominant types encountered all through the year greater concentration of *Aspergilli* occurred in May–December; *Nigrospora* and *Curvularia* in August–December; *Alternaria* in May, November and January; basidiospores in May–August; Chlamydospores in June–March; uredospores, *Periconia* and *Helminthosporium* in December–April. Atmospheric pollution by *Lacellinopsis* was greater in two periods- July–August and January–March. Other types which were caught in considerable numbers include *Trichoconis* in the period October–November; *Cercospora* in September–November; *Pithomyces* in October–January; *Oidium* in August and November–March;

Fig. 1.

Day to day atmospheric incidence of the ten pollen types at Anakapalle.

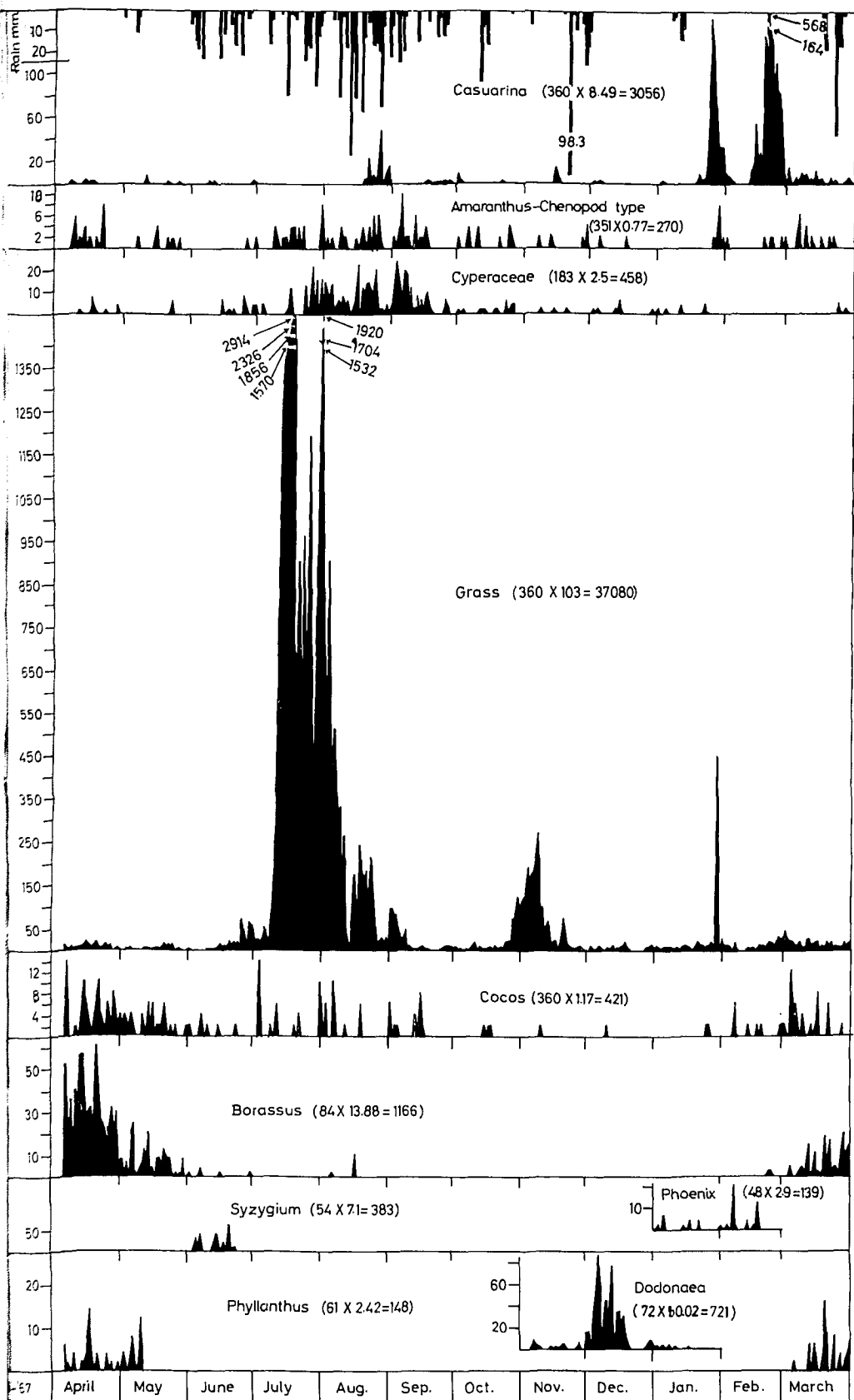


TABLE 2
Relative Incidence of Different Fungus Spore Types

Spore type	Seasonal total no. per sq. cm			% contribution to the total fungal air spora		
	A	V	V*	A	V	V*
1. Cystopus	60	2	52	0.032	0.001	0.064
2. Sporormia	30	80	64	0.016	0.049	0.078
3. Chaetomium	38	74	—	0.020	0.046	—
4. Leptosphaeria	34	32	8	0.018	0.020	0.010
5. Podaxis	152	96	62	0.081	0.059	0.079
6. Ganoderma	8	46	58	0.004	0.028	0.071
7. Botryodiplodia	90	58	108	0.048	0.036	0.133
8. Spegazzinia	66	40	92	0.035	0.025	0.113
9. Papularia	674	—	—	0.357	—	—
10. Piricularia	26	16	26	0.014	0.010	0.032
11. Beltrania	6	22	14	0.003	0.013	0.017
12. Dendryphiella	142	68	12	0.075	0.042	0.015
13. Cephalophora	12	70	48	0.006	0.011	0.059
14. Fusarium	154	30	20	0.082	0.015	0.024
15. Deightonella	8	18	14	0.004	0.010	0.017
16. Neovossia	26	6	4	0.014	0.004	0.005
17. Corynespora	150	324	132	0.079	0.200	0.162
18. Phaeotrichoconis	82	138	122	0.043	0.086	0.150
19. Cercospora (short)	124	560	894	0.066	0.350	1.097
20. Cercospora (long)	212	290	260	0.112	0.180	0.319
21. Hyaline rods	880	1508	222	0.466	0.930	0.272
Unclassified	16220	13336	8880	10.020	8.240	10.900
Total spores	188790	161934	81490	100.000	100.000	100.000

A = Anakapalle, 1966-'67.

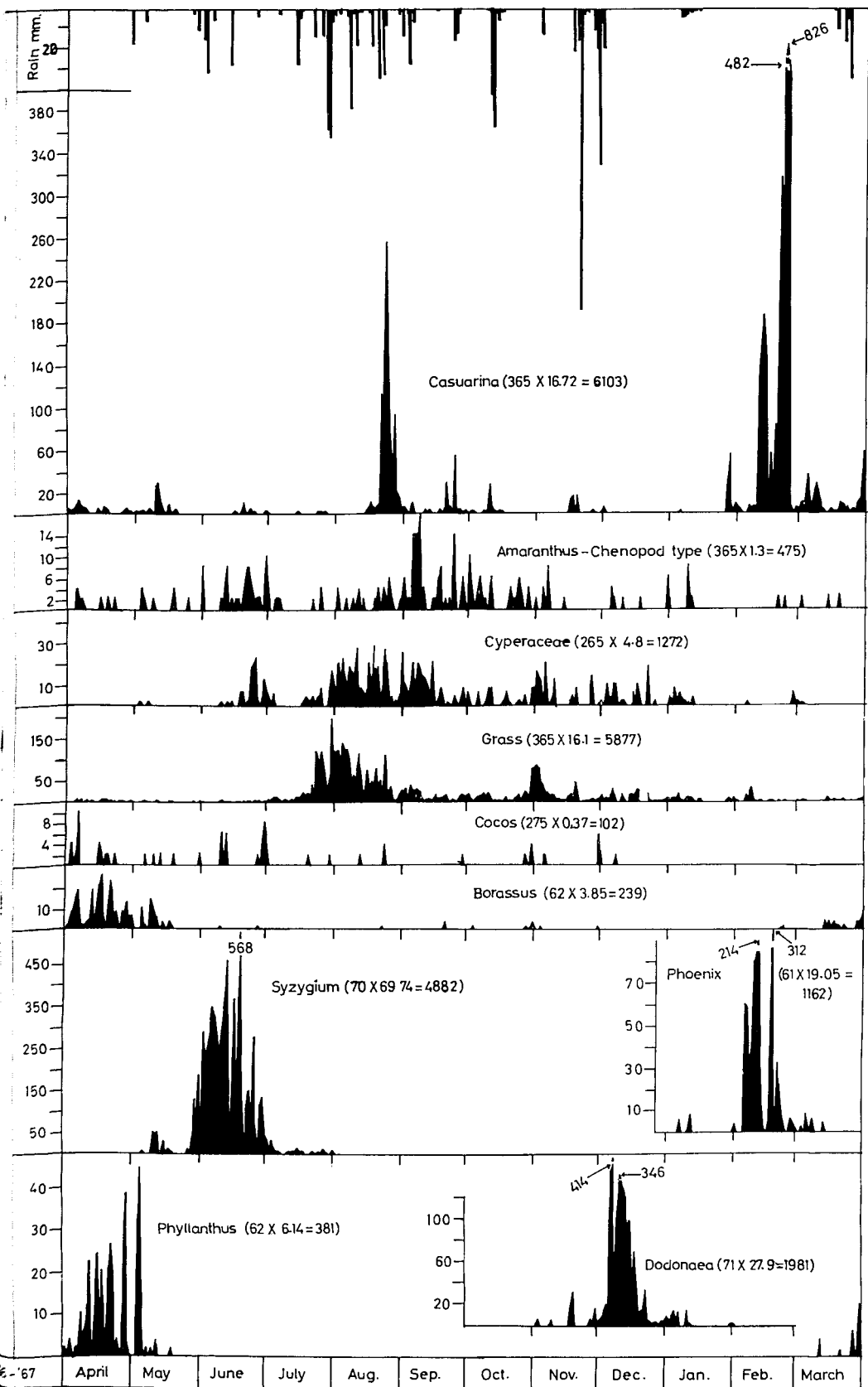
V = Visakhapatnam, 1966-'67.

V* = Visakhapatnam, 1967-'68.

ascospores, *Pleospora* and *Sclerospora* in July–September. Other types of considerable importance caught sporadically were *Tetraploa*, *Torula*, *Corynespora*, *Cephalophora* and *Podaxis*.

Fig. 2.

Day to day atmospheric incidence of the ten pollen types at Visakhapatnam.



Comparison of the Catches at Anakapalle and Visakhapatnam in One Year

The data presented in Tables 1 and 2 for the year 1966-'67 indicate that the total pollen and fungus spore catches were greater at Anakapalle and the estimated daily means of pollen and fungus spores both at Anakapalle and Visakhapatnam being 142: 68 for pollen and 563: 469 for fungus spores respectively. This means that the pollen contribution to the total air-spora was only 20 per cent at Anakapalle and 13 per cent at Visakhapatnam. Inspite of these quantitative variations the two sites showed no major differences in the identity of the pollen and fungus spores caught.

An analysis of the incidence of atmospheric pollen at the two places presented in Table 3 indicate that at Visakhapatnam the tree pollen collectively dominated and at Anakapalle the grass pollen preponderated the total pollen catch. Among the tree types *Casuarina* and among the weed types Cyperaceous were found to be the dominant components at the two places.

The number of days in which the particular pollen type occurred and the estimated daily mean count (as was given by Hyde 1959) given in Fig. 1 and 2 indicated the relative importance of these ten pollen types at the two stations. Among them (Fig. 1 and 2) pollen of Gramineae (mostly comprising *Pennisetum* type coming from the crop in the vicinity), *Borassus*, *Cocos* were more abundant at Anakapalle while the remaining types were more numerous at Visakhapatnam. The data presented in Figs. 1 and 2 also indicate the variations existing in the highest daily catches and their dates of occurrence.

Certain differences were noticed in the general course of the pollen incidence between the two sites as witnessed by the monthwise distributions of *Casuarina*, *Cocos* and *Amaranthus*-

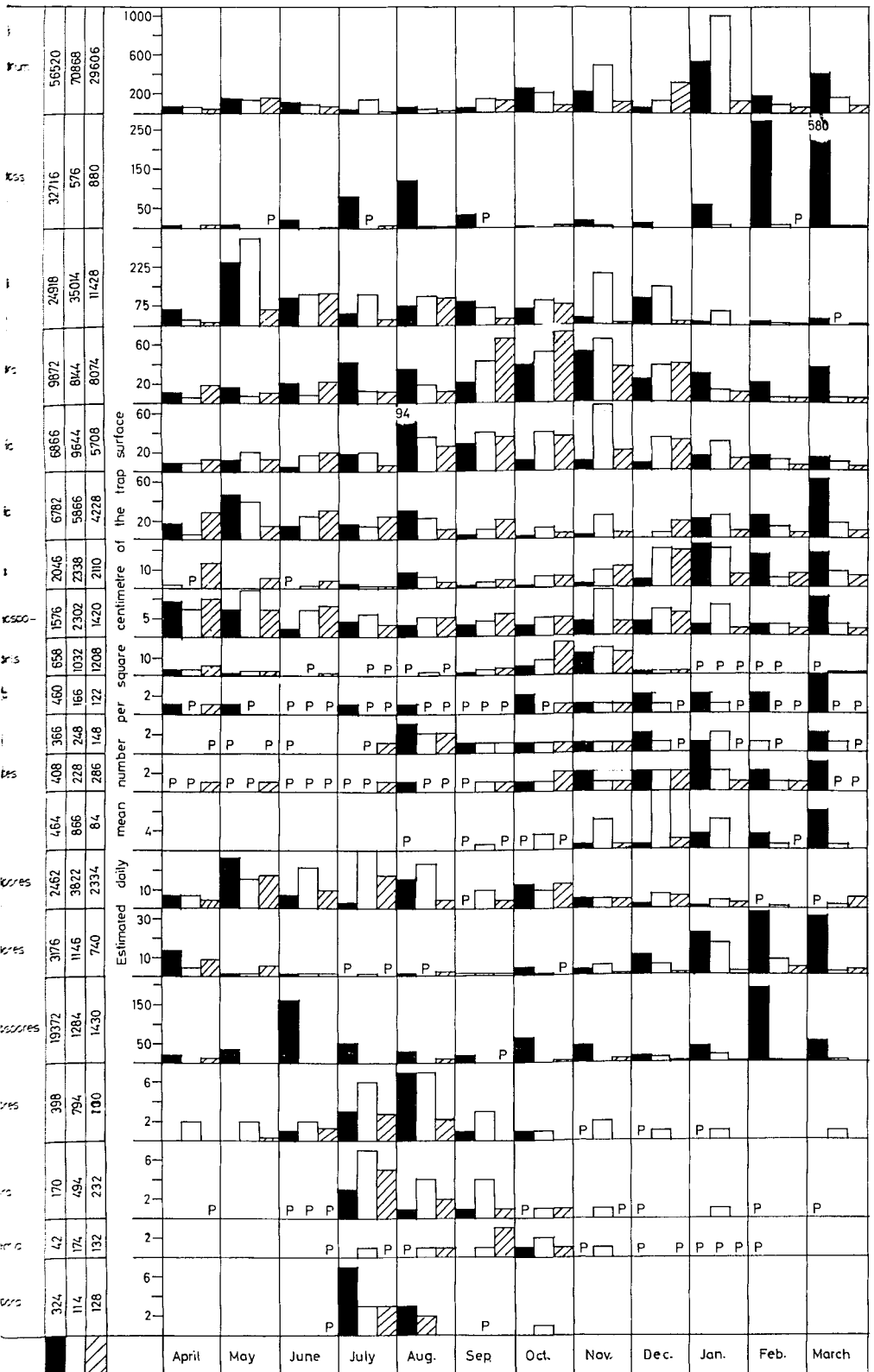
Fig. 3.

Relative incidence of the twenty fungus spore types at the two sites.

P denotes less than one estimated daily mean.

■

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Name of group	No. of types identified			No. of AKP
	AKP	VSP	VSP*	
1. Gramineae	1	1	1	38,988
2. Weeds	8	10	7	1,014
a) Anemophilous	4	4	4	
b) Entomophilous	4	6	3	
3. Trees and shrubs	19	25	25	5,646
a) Anemophilous	8	8	8	
b) Entomophilous	11	17	17	
Total Anemophilous	13	13	13	44,910
Total Entomophilous	15	23	20	738
4. Damaged and unidentified				1,800
Totals	28	36	33	47,448

AKP = Anakapalle, 1966-'67.

VSP* = Visakhapatnam, 1967-'68.

Chenopod types (see Table 1). In the case of *Casuarina* though the seasonal peak occurred in February at both the places, the January catch was smaller than that of March at Visakhapatnam, while at Anakapalle the reverse happened.

Though *Cladosporium* and *Aspergilli*, the chief constituents of the fungal air-spores gave higher counts at Visakhapatnam, the fungus spore catch as a whole was greater at Anakapalle. In general spore types like Chlamydospores, uredospores, *Alternaria*, *Nigrospora* coming from the crop plants and other types like *Lacellinopsis*, *Pithomyces*, *Torula*, and *Tetraploa* were more numerous at Anakapalle. Relatively higher numbers of basidiospores and *Cercospora* were caught at Visakhapatnam. The ascospore catch which includes aco-spores, *Pleospora*, *Pringsheimia* and *Sporormia* was about two and half times greater at Visakhapatnam. The incidence of *Papularia* occurred only at Anakapalle.

Certain differences in the seasonal incidence of some fungus spore types were also noticed. At Visakhapatnam high con-

Various Groups in the Total Pollen Catch.

Grains/Sq. cm		Percentage of the total catch		
VSP	VSP*	AKP	VSP	VSP*
4,916	4,734	82.17	21.06	31.43
1,744	1,804	2.14	7.83	11.98
1,558	1,680	1.92	6.68	11.15
186	124	0.22	0.80	0.83
15,530	7,464	11.91	66.39	49.55
8,824	3,654	10.56	37.81	24.25
6,706	3,810	1.34	28.70	25.30
15,298	10,068	94.65	65.55	66.83
6,892	3,934	1.56	29.50	26.13
1,158	1,060	3.79	4.95	7.04
23,348	15,062	100.00	100.00	100.00

VSP = Visakhapatnam, 1966-'67.

centrations of *Curvularia* occurred in November and at Anakapalle in August. A smooth running up of the *Nigrospora* season with a peak in November was noticed at Visakhapatnam, whereas at Anakapalle peaks were recorded in July-August, October-November, January and March.

Comparison of the Catches at Visakhapatnam in Two Consecutive Years

Despite the quantitative variations observed in the incidence of the different components of the air-spores, no recognizable qualitative differences were noticed in the two years. The total catch of pollen and fungus spores was greater in 1966-'67, the day's means being 637 (469 fungus spores; 68 pollen) in 1966-'67 and 313 (264 fungus spores; 49 pollen) in 1967-'68. The incidence of spore types like *Cladosporium*, *Aspergilli*, uredospores, *Curvularia*, *Nigrospora*, *Alternaria*, *Helminthosporium*, *Oidium* and *Pleospora* was higher in

1966-'67. In 1967-'68 slightly higher numbers of *Trichokonis*, *Lacellinopsis*, *Pithomyces* and *Cercospora* occurred. Though there were no major differences in the general course of the seasonal incidence of the different spore types, the periods of maximal concentrations varied for types like *Cladosporium*, *Aspergilli*, basidiospores and *Alternaria*.

From the results presented in Table 3, it could be seen that the tree pollen catch in 1966-'67 was twice that in 1967-'68, *Casuarina*, *Phoenix*, *Dodonaea* and *Syzygium* being responsible for these higher counts. *Cocos*, *Embllica*, *Morus*, *Ricinus* and *Bassia* gave higher counts in 1967-'68. Certain differences in the course of the grass and weed pollen incidence are evident from the data presented in Table 1 and these differences could be related to the differences in the amount of rainfall and its distribution in each of the two years.

Comparison of the Results of the Present Study with the Results of the Earlier Studies in India

The results of pollen incidence recorded in the present study with a vertical cylinder when compared with those carried out at Delhi (*Shivpuri et al.* 1960, *Dua & Shivpuri* 1962), Jaipur (*Kasliwal et al.* 1959), Lucknow and Almora (*Lakhanpal & Nair* 1958, 1960) and Gauhati (*Baruah & Chetia* 1965) where air sampling was done with the gravity slide method, indicated that only few pollen types are common to all these places and *Holoptelea* pollen dominated the air at Lucknow and Jaipur, that of *Quercus* at Almora, that of grasses at Gauhati and Anakapalle, that of grasses and the trees collectively at Delhi and Visakhapatnam. Types like *Borassus*, *Cocos*, *Casuarina* and *Peltophorum* were recorded in the present study only. It is interesting to note that although some half a dozen plants of *Holoptelea*, (known to produce large numbers of pollen) were located within three miles distance from the trapping site at Visakhapatnam, only few grains of *Holoptelea* were encountered in the catches from February to May. That the periods of onset and progress of the pollen seasons

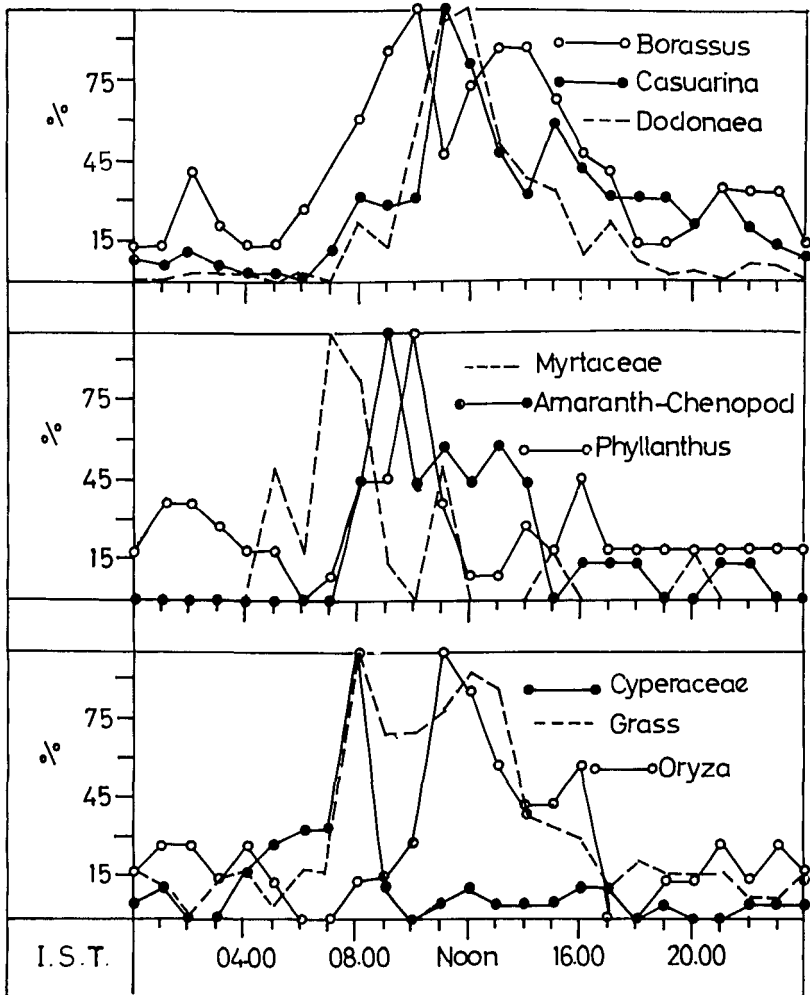


Fig. 4.

Mean diurnal periodicity curves for the nine pollen types expressed as percentage of the peak arithmetic mean concentration.

varied at the different places was evident from this comparison. For instance *Phoenix* pollen season was from February to April at Delhi, from September to February at Jaipur and from January to March at Visakhapatnam and Anakapalle.

The results of the pollen and spore catches recorded in the present study using the cylinder trap when compared with those of *Sreeramulu & Ramalingam* (1966) and *Ramalingam* (1966) who used a Hirst trap for air sampling showed general agreement in the patterns of incidence of total pollen and fungus spores. The variations (especially those found in the catches of the wet spora elements) in these two studies could be related to the differences in the catching efficiencies of the traps used, the heights at which they were installed and the variations in the surrounding vegetation.

Hourly Changes in the Pollen Content of the Air

The mean diurnal periodicity curves derived from the Hirst trap data are presented as percentages of peak arithmetic mean concentration in Fig. 4. The estimated mean concentration (number per m³) at the peak hour of the days selected (number of which is given in brackets for each of the nine pollen types) are: *Borassus*, 255 (34); *Casuarina*, 612 (9); *Dodonaea*, 1934 (8); Myrtaceae, 102 (27); *Amaranthus-Chenopod* type, 119 (17); *Phyllanthus*, 187 (21); Cyperaceae, 266 (5); Grass, 391 (13) and *Oryza*, 119 (7). Distinct diurnal periodicity patterns were observed for all the pollen types with higher concentrations occurring in the air between 0800 and 1600hrs. and low numbers in the intervening period. The time of day at which peak numbers occurred varied for different types: maximum incidence of pollen of Myrtaceae occurred at 0700 hrs.; that of Cyperaceae and Grass at 0800 hrs.; *Amaranthus-Chenopod* type at 0900 hrs.; *Borassus* and *Phyllanthus* at 1000 hrs.; *Casuarina* and *Oryza* at 1100 hrs.; and *Dodonaea* at noon.

The diurnal periodicity pattern observed for the pollen of Cyperaceae differed from the rest as it showed a sharp increase to a peak at 0800 hrs. followed by a sudden decrease which could be related to the sharp decrease in relative humidity and increase in temperature in the air. During field observations it was found that the anthers in the spikelets would

be in a turgid state for a short while after dawn. After dehiscence was over by 0700 to 0800 hrs. the anthers were seen to dry up very quickly. This sudden drying of the anthers leading to hygroscopic changes affect further liberation of pollen.

DISCUSSION

Differences in the composition of the local vegetation, ecological changes and the variations in rainfall and other seasonal factors recorded at the two stations (Anakapalle and Visakhapatnam) account for the considerable variability found in the actual numbers of pollen and fungus spores caught at these two sites. As every pollen type encountered at both the places could be accounted for locally, the incidence in air of the different types of pollen is also influenced by the variations in the flowering periods of the different species in each locality.

A ratio of 1:4 for pollen to fungus spores was recorded for Anakapalle, whereas for Visakhapatnam the ratio was 1.7:10. The total pollen catch at Visakhapatnam in 1966-'67 was about 50 per cent lower than that at Anakapalle, grass pollen being responsible for the higher counts. The observed dominance of grass pollen at Anakapalle is in agreement with *Hyde* (1952) who reported higher incidence of grass pollen at places with cultivable land. The total pollen catch in 1966-'67 was about 35 per cent greater than that in 1967-'68. A great fluctuation was noticed in tree pollen incidence in two consecutive years at Visakhapatnam. Similar trends in the year to year incidence of tree pollen were recorded at Cardiff, Wales (*Hyde* 1956) and at Delhi in India (*Dua & Shivpuri* 1962).

Richards (1956) and *Hamilton* (1959) in England and *Gordon* (1957) in America reported higher incidence of fungus spores in rural areas than in urban areas. In the present study also greater incidence of fungus spores and pollen was recorded at Anakapalle, the rural locality. The total counts of fungus spores in 1966-'67 at Visakhapatnam were 17 per cent lower than at Anakapalle and they were 44 per cent

greater than those of 1967-'68. *Cladosporium*, which has been recorded in greater abundance in many studies at rural areas showed higher incidence at Visakhapatnam, the urban locality but an inspection into the month-wise distributions revealed that the catches from February to June were higher at Anakapalle, and those from July to January with the exception of August were greater at Visakhapatnam. This difference could be correlated to the availability of dead and decaying vegetable matter. Despite these monthly variations the *Cladosporium* season with its peak in January ran on similar lines at both the places, thus agreeing with the report of *Barat & Nandi* (1966) who observed similarities in the general course of the incidence of *Cladosporium* at rural and urban localities in West Bengal. The recorded higher incidence of *Aspergilli* at Visakhapatnam was in agreement with *Richards* (1956) and *Hamilton* (1959) who recorded higher incidence of *Aspergillus* and *Penicillium* at urban localities. The variations in the numerical incidence of certain types was very striking. For instance the numbers of *Lacellinopsis* were 75 times more at Anakapalle than at Visakhapatnam, it being an ubiquitous saprobe on the dead and decaying leaves of sugarcane. Thus as has been shown by *Hamilton* (1959) and *Lacey* (1962) (who reported that the ecology and local vegetation enormously influence the kinds and quantities of the air-spora at a particular area) the differences observed in the pollen and spore catches between these two stations could be related to the availability of suitable vegetation, proximity and strength of sources. It also depended on the amount of total precipitation and its annual distribution. The variations encountered in the catches of pollen and spores in two consecutive years at Visakhapatnam could be ascribed to the seasonal differences.

Besides exhibiting marked seasonal periodicities, different pollen types displayed distinct diurnal periodicities in their atmospheric incidence. Major part of the pollen rain in a day appeared in the forenoon hours. However, this may vary with different types: Pollen of Myrtaceae at 0700 hrs.: Cyperaceae and grass at 0800 hrs.; *Amaranthus*-*Chenopod* at 0900 hrs.;

Borassus and *Phyllanthus* at 1000 hrs.; *Casuarina* and *Oryza* at 1100 hrs.; and *Dodonaea* at noon. It was observed that Cyperaceous pollen was emitted during a short period and a similar trend was noticed for *Acalypha* by Pady *et al.* (1967) at Kansas.

Most of the pollen types encountered in this study fulfil the postulates laid down by Thommen (1931) for plants causing hayfever and asthma. These types include the grasses, Cyperaceae, *Amaranthus*-Chenopod type, *Phyllanthus*, *Syzygium*, *Dodonaea*, *Phoenix*, the allergenicity of which was proved by Kasliwal & Solomon (1958), Shivpuri & Singh (1965). Among the other types *Casuarina* was found to be responsible for allergy in Florida (Zivitz 1942) and the allergenicity of *Pongamia* and *Peltophorum* have yet to be proved. Following Thommen (1931), Hyde & Williams (1946) postulated certain requirements in regard to those kinds of fungus spores which are likely to cause asthma. Among the fungus spores encountered in this study *Cladosporium*, *Aspergilli*, basidiospores, *Alternaria*, *Nigrospora*, *Curvularia*, *Periconia*, and ascospores were present in air in appreciable numbers for a sufficient length of time and these may form potential hazards to sensitive individuals. At Anakapalle, *Lacellinopsis*, Chlamydo-spores and uredospores may be added to the above. *Pithomyces* which occur in these areas was shown to be responsible for facial eczema in sheep in England (Lacey & Gregory 1962) and in New Zealand (Filmer 1961).

The present air sampling study (conducted with glass cylinder of 0.53 cm diameter known to have a relatively higher catching efficiency than the widely used gravity slide) revealed that the atmosphere at Anakapalle and Visakhapatnam was never free of pollen and fungus spores. The information on pollen and fungus spore content of the air gathered in this study will serve as a helpful guide to the kinds and quantities of air-borne pollen and fungus spores in these areas. In view of the common occurrence of allergic diseases in India (Kasliwal *et al.* 1955) it is worth-while undertaking long term surveys of air-borne pollen and spores along with clinical studies in different

parts of India as an aid to the clinician for a better diagnosis and treatment of inhalant allergy, as was done in the U. S. A., U. K. and other European countries.

SUMMARY

The atmospheric concentration of different pollen and fungus spore types as measured by the catches on sticky cellophane strips (18 sq. mm.) wound round the glass cylinders (0.53 cm diameter) exposed for 24-hour periods was studied at Anakapalle and Visakhapatnam, twenty miles apart which could be taken as representatives of the rural and urban localities respectively.

The seasonal periodicities of the various pollen and spore types recorded with the cylinder trap at both the places were described. At both the places the maximum atmospheric concentration of anemophilous tree pollen was found in February and to some extent in April. The grass pollen incidence in the air was greater in the period July–August. Weed pollen was encountered in higher concentrations during August and September. Though the fungus spores were caught all through the year, maximum incidence was noticed in February–May.

Pollen from anemophilous plants preponderated the catches, the entomophilous catch being 27 per cent at Visakhapatnam and 1.6 per cent at Anakapalle. Pollen from *Casuarina*, *Dodonaea*, *Borassus*, *Phyllanthus*, *Phoenix*, *Cocos*, and *Syzygium* formed the major part of the tree pollen, *Casuarina* being the dominant type at both the sites. Major part of the weed pollen came from Cyperaceae and Amaranthaceae-Chenopodiaceae, with the former as the predominant type at both the sites. As a whole grass pollen predominated the catches at Anakapalle. Tree pollen collectively and the grass pollen were equally important at Visakhapatnam. Among the fungus spores *Cladosporium*, *Aspergilli*, *Nigrospora*, *Alternaria*, *Curvularia*, basidiospores, ascospores, *Periconia*, uredospores, *Helminthosporium*, Chlamydospores of smuts and *Lacellinopsis* were the prevailing types. *Cladosporium* was recognised as the domi-

nant spore type at the two sites. The comparison between the catches obtained in 1966-'67 at Anakapalle and Visakhapatnam indicated that the incidence of both pollen and fungus spores was greater at Anakapalle and the variations observed in the numerical incidence and the general course of the season were found to be related to the differences in the local vegetation, proximity of the sources to the air samplers and the fluctuations in the weather.

The comparison made between the catches obtained at Visakhapatnam in two consecutive years revealed certain differences both in the numerical incidence and the course of the seasons. The incidence of tree pollen fluctuated very widely in the two years. The differences noticed in the grass and weed pollen incidence in the two years were related to the variations in the amount of rainfall and its distribution in each of the two years.

An analysis of the data obtained by scanning the slides exposed in the Hirst trap showed well-marked diurnal rhythms in the incidence of various pollen types. The daily peaks recurred at 0700 hrs. for Myrtaceae; at 0800 hrs. for grass and Cyperaceae; at 0900 hrs. for *Amaranthus*-*Chenopod* type; at 1000 hrs. for *Borassus* and *Phyllanthus*, at 1100 hrs. for *Casuarina* and *Oryza* and at noon for *Dodonaea*.

A comparison of the pollen catches obtained in the present study with those of earlier records from different places in India showed that the distribution of the air-borne allergens varied both in variety and magnitude from place to place and from year to year. The significance of the different pollen and spore types caught at Anakapalle and Visakhapatnam as potential causes of allergic diseases was discussed and the need for undertaking detailed long term surveys was emphasised.

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