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# Contributions to the Aerobiology of Shillong. I. Studies on the Seasonal Variation of Atmospheric Pollen and Fungal Spores

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Total air-spora, pollen grains, fungal spores and other biological materials constituted 22, 72 and 6% respectively. The low incidence of pollen in atmosphere was mainly due to high altitude of the place and may also be due to less number of anemophilous plants in the locality. Pollen flora showed three peak periods: March, May and September, and each period was dominated by a specific pollen type. There was a distinct correlation between wind velocity and concentration of pollen in the atmosphere. Low frequency of pollen during June-August is probably due to heavy rainfall, which washed down the pollen.

The frequency of the fungal spores was maximum during September (very high humidity) and minimum in March (low humidity) with two peak periods in June and September. Further, the cause of seasonal fluctuations of air-borne dominant fungal spores is discussed.

**Key Words:** **Aerobiology, Environmental factors, Fungal spore, Pollen grains, Seasonal variation**

## Introduction

A wide variety of micro-organisms constitutes the air-spora of any region (Sreeramulu 1967) and these are dispersed from the source by various agents. Some of these have been known to be pathogenic to plants and animals. The incidence patterns of air-borne particulate matters differ from place to place and season to season. A knowledge of the occurrence of air-borne pathogens is helpful in controlling the diseases. Some aerobiological studies conducted in India in the last decades reveal the qualitative and quantitative features of air-flora in different parts of the country (Rajan et al. 1952, Sanghvi et al. 1957, Kalra & Dumbrey 1957, Lakhanpal & Nair 1958, Sreeramulu 1959, 1967, Shivpuri et al. 1960a, b, Karnik 1962, Sreeramulu & Ramalingam 1964, 1966, Chaubal & Deodikar 1964, Subba Reddi 1970, Ramalingam 1971, Vishnu-Mittre & Khandelwal 1975,

Rajkumar & Gupta 1975, Gaur 1978, Bhati & Gaur 1979, Singh & Baruah 1979, Singh & Babu 1980, Gaur & Kasana 1981, Jain & Das 1981). In eastern India systemic aerobiological studies were initiated by Chanda and his coworkers (Chanda & Nandi 1971, Chanda & Sarkar 1972, Chanda 1973, Chanda & Mandal 1976). Studies on air-borne pollen in greater Calcutta and Pollination Calendei of Calcutta, Falta and Kalyani have already been published. Further, these studies pertain to plains where more or less similar results have been obtained, while studies on hilly regions are conspicuously lacking, except for few scattered accounts (Singh & Baruah 1979, Singh et al. 1981, Singh 1981).

The present study concerns the seasonal variations of air-borne spores and pollen grains in a hilly area, viz., Shillong.

## Area of Study

Shillong lies between 23°54'N and 91°54'E and the altitude varies from 1050 to 1990m (Shillong peak, the highest peak in Meghalaya). Physiographically, the area is hilly with steep escarpments having shallow or deep valleys with swift flowing rivers and streams. The vegetation dominated by *Pinus kesiya* (Khasi pine) with a number of angiosperms in high or low occurrence can broadly be classified as: (*i*) Subtropical Pine Forest, (*ii*) The rolling grasslands, and (*iii*) Mixed ever-green Forest.

The approximate elevation of the site of spore traps in Shillong proper was 1200m.

## Materials and Methods

Spores, pollen and other particulate matters of biological origin, were trapped on glycerine jelly smeared slides by simple gravity slide method using an Aeroscope (Lakhanpal & Nair 1958) (supplied by All India Co-ordinated Project on Aerobiology). The Aeroscope was placed at about 10m. height above ground level on the terrace of a University building. This site was comparatively open in the immediate vicinity but surrounded by vegetation.

Microscope slide smeared with saffranin-stained glycerine jelly was exposed in vertical position inside the sampler protected from rain water and observed every 24 hr. Extraneous particles like sand, etc. if present were removed and the slide was then heated gently to remove moisture and covered. Observations and counts were made from each slide from left to right and then from above downwards. The various categories of bio-pollutants trapped were counted/$cm^2$/day, and the percentage of these bio-pollutants/month was calculated.

The air-borne pollen were later identified with the help of reference pollen slides of common flowering plants in the area and also based on the flowering times (phenology chart) of these plants.

### *Key to Identification of Pollen*

The following key is purely artificial. Only important morphological characters are used and these refer to the pollen studied from the anthers collected from the ground vegetation of Shillong and its environs. Where it is not possible to key out up to the species level in certain families, such as Poaceae and Cyperaceae, the key refers to the group as a whole.

1*a*. Pollen grains in Polyads
- 2*a*. Exine psilate...*Acacia dealbata*
- 2*b*. Exine granulose...*Albizia* sp.

1*b*. Pollen grains in tetrads
- 3*a*. Pollen grains 54 μ in diam...*Rhododendron arboreum*
- 3*b*. Pollen grains 35.5 μ in diam...*Gaultheria fragrantissima*
- 3*c*. Pollen grains 30 μ in diam...*Lyonia ovalifolia*
- 3*d*. Pollen grains 44 μ in diam...*Vaccinum* sp.

1*c*. Pollen grains free
- 4*a*. Inaperturate...*Cupressus torulosa*
- 4*b*. Aperturate
  - 5*a*. Aperture simple
    - 6*a*. 1-Colpate
      - 7*a*. Pollen grains saccate
        - 8*a*. Marginal crest well developed...*Pinus kesiya*
        - 8*b*. Marginal crest not well developed...*Cedrus deodara*
      - 7*b*. Pollen grains non saccate
        - 9*a*. Aperture papillate...*Cryptomeria japonica*
        - 9*b*. Aperture non papillate...*Disporum pullum*
    - 6*b*. 3-Colpate
      - 10*a*. Exine psilate
        - 11*a*. Pollen grains subprolate
          - 12*a*. Pollen grains 36 μ in diam...*Brunella vulgaris*
          - 12*b*. Pollen grains 44 μ in diam...*Eucalyptus globulus*
          - 12*c*. Pollen grains 72 μ in diam...*Schima khasiana, Schima wallichii*
          - 12*d*. Pollen grains 84 μ in diam...*Fagopyrum esculantum*
        - 11*b*. Pollen grains oblate...*Callistemon lanceolatum*
        - 11*c*. Pollen grains prolate...*Ranunculus contoniensis*
      - 10*b*. Exine reticulate
        - 13*a*. Pollen grains spheroidal
        - 14*a*. Pollen grains 50 μ in diam...*Lantana camara*
        - 14*b*. Pollen grains 50 μ in diam...*Duranta plumeri*
        - 13*b*. Pollen grains subprolate...*Corylopsis himalayana*
      - 10*c*. Exine granulose
        - 15*a*. Pollen grains spheroidal...*Symplocos spicata*
        - 15*b*. Pollen grains prolate spheroidal...*Fumaria* sp.
      - 10*d*. Exine spinose...*Abutilon indicum*
      - 10*e*. Exine spinulose...*Clerodendrum serratum*
    - 6*c*. Pentocolpate; Exine foveolate...*Anemone rivularis*
    - 6*d*. Porate
      - 16*a*. Pollen grains 1-Porate
        - 17*a*. Exine granulose...*Gramineae*
        - 17*b*. Exine psilate...*Cyperaceae*
      - 16*b*. Pollen grains 3-Porate
        - 18*a*. Pores aspidote
          - 19*a*. Aspis high...*Oenothera* sp.
          - 19*b*. Aspis low
            - 20*a*. Pollen grains circular to subtriangular...*Betula* sp.
            - 20*b*. Pollen grains rectangular.. *Alnus* sp.
        - 18*b*. Pores not aspidote
          - 21*a*. Exine reticulate...*Urticaceae*
          - 21*b*. Exine psilate.. *Eleocarpus accuminatus*

16*c*. Pantoporate
22*a*. Exine psilate
23*a*. Pollen grains prolate...*Thalictrum* sp.
23*b*. Pollen grains spheroidal...*Engelhardtia spicata*
22*b*. Exine granulose-spheroidal
24*a*. Pollen grains 23 $\mu$ in diam...*Alternanthera* sp.
24*b*. Pollen grains 35 $\mu$ in diam...*Chenopodium* sp.
22*c*. Exine reticulate
25*a*. Pollen grains 32 $\mu$ in diam...*Amaranthus* sp.
25*b*. Pollen grains 45 $\mu$ in diam...*Polygonum hydropiper*
25*c*. Pollen grains 36 $\mu$ in diam...*Dephne Shillong*
22*d*. Exine psilate...*Sarcococca* sp.
22*e*. Exine spinose
26*a*. Exine with columella...*Convolvulaceae*
26*b*. Exine without columella...*Malvaceae*

5*b*. Apperture composite...colporate
27*a*. Exine psilate
28*a*. Pollen grain subprolate
29*a*. Endocolpium lalongate
30*a*. Flowering period in Sept-Nov....*Castenopsis* sp.
30*b*. Flowering period in April-June...*Castanea* sp.
30*c*. Flowering period in Jan-Feb....*Quercus dealbata*
30*d*. Flowering period in June...*Quercus griffithii*
29*b*. Endocolpium circular
31*a*. Pollen grains 44 $\mu$ in diam...*Photinia notoniana*
31*b*. Pollen grains 88 $\mu$ in diam...*Prunus domestica*
31*c*. Pollen grains 80 $\mu$ in diam...*Prunus nepalensis*
31*d*. Pollen grains 76 $\mu$ in diam...*Prunus cerasoides*
31*e*. Pollen grains 15 $\mu$ in diam
32*a*. Flowering period in Aug-Oct....*Rubus acuminatus*
32*b*. Flowering period in Sept-Nov....*Rubus assamensis*
31*f*. Pollen grains 22 $\mu$ in diam...*Rubus ellipticus*
28*b*. Pollen grain spheroidal
33*a*. Pollen grain 33 $\mu$ in diam.
34*a*. Flowering period Feb-March.. .*Pyrus communis*
34*b*. Flowering period June-July.. .*Rubus micropetalous*
33*b*. Pollen grain 44 $\mu$ in diam.. .*Prunus accuminatus*
33*c*. Pollen grain 24 $\mu$ in diam.. .*Osbeckia* sp.
27*b*. Exine reticulate....spheroidal
35*a*. Pollen grain 18 $\mu$ in diam.. .*Ardisis macrocarpa*
35*b*. Pollen grain 14 $\mu$ in diam.. .*Neillia thrysiflora*
35*c*. Pollen grain 44 $\mu$ in diam.. .*Rhus khasiana*
35*d*. Pollen grain 22 $\mu$ in diam.. .*Glochidion* sp.
27*c*. Exine spinose
36*a*. Pollen grain spheroidal.. .*Ageratum conyzoides*
36*b*. Pollen grain prolate spheroidal.. .*Anaphalis* sp.
27*d*. Exine granulose
37*a*. Pollen grain sub-oblate
38*a*. Endocolpium circular.. .*Macropanax* sp.
38*b*. Endocolpium not circular
39*a*. Pollen grain 27 $\mu$ in diam.. .*Panax* sp.
39*b*. Pollen grain 20 $\mu$ in diam.. .*Ambrosia* sp.
37*b*. Pollen grain prolate spheroidal.. .*Artemisia* sp.
37*c*. Pollen grain sub-prolate...*Erigeron* sp.

*Trapping and Identification of Fungal Spores*

For identification of fungal spores, culture plate method was used (Hyde & Williams 1946), three Petri dishes containing Czapek's culture medium were exposed for 7 min near the spore trap, and then incubated at 27°C±1°C for 6 days. The fungal colonies were isolated, examined and identified. Spores were also identified using standard literature (Barnett 1955, Subramanian 1971).

## Results and Discussion

Pollen and spores constitute an important fraction of the total particulate level of the atmosphere. Concentration of pollen in the atmosphere is usually determined by the stage of flowering of the various anemophilous species and the meteorological conditions of the area. Hardly any period is free from the atmospheric bio-pollutants. Though the flora of Shillong is very rich and diverse, the percentage occurrence of the pollen grains is rather less. Only 63 air-borne pollen types, constituting about 21% of the total bio-pollutants, have been observed (figure 1). This may be due to the fact that the pollen production decreases quantitatively with the increasing altitude (Ludi 1937, Markgraf 1980). Further, the heavy rainfall in this region which is spread over 6–8 months of the year is probably responsible for low incidence. This is in conformity with the earlier findings (Sreeramulu & Ramaiingam 1964, Ramalingam 1967, Mc Donal 1979).

There are three peak periods of the pollen concentrations which correspond to March, May and September respectively (figure 2). March is mainly predominated by the pollen of *Pinus* and other Gymnosperms as well as grasses (figure 3a & b) which rather form a conspicuous feature of vegetation of Shillong. The effect of weather conditions on the occurrence of pollen in the atmosphere has been well established (Hirst 1953, Karnik 1962, Sreeramulu & Ramalingam 1964, Ebell & Schmidt 1964, Ramalingam 1967). Further, during this period the temperature ranges from 20–22°C which favour the pollen production and its distribution/dispersal. The month of May is also predominated by pine pollen and pollen of angiosperms like *Schima wallichii*, *Quercus* sp., *Viburnum* sp. and members of Rosaceae and Asteraceae. This also coincides with the phenology of these species. Very negligible pollen counts during June, August is probably due to the very high rainfall which the area receives. Heavy rainfall not only lowers the pollen production in a species but also washes down the pollen from the atmosphere (Hyde & Williams 1945, Sreeramulu & Ramalingam 1964, Ramalingam 1967, McDonal 1979). Again the atmosphere in September is dominated by the pollen of *Cedrus* sp., *Betula*

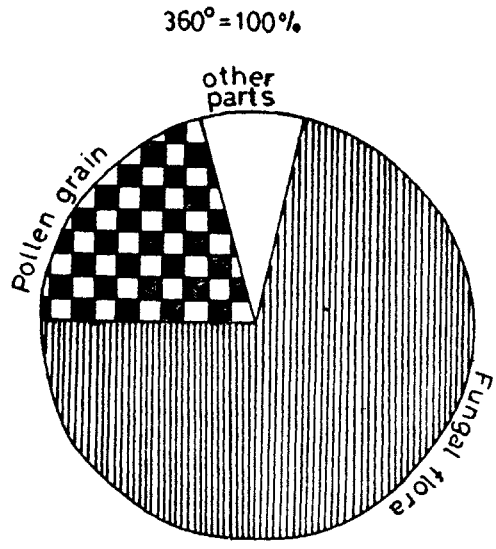


**Figure 1** Air-spora of Shillong

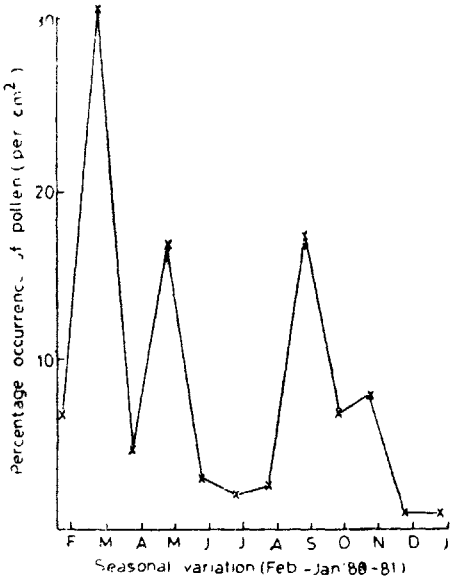


**Figure 2** Seasonal variation of pollen concentration

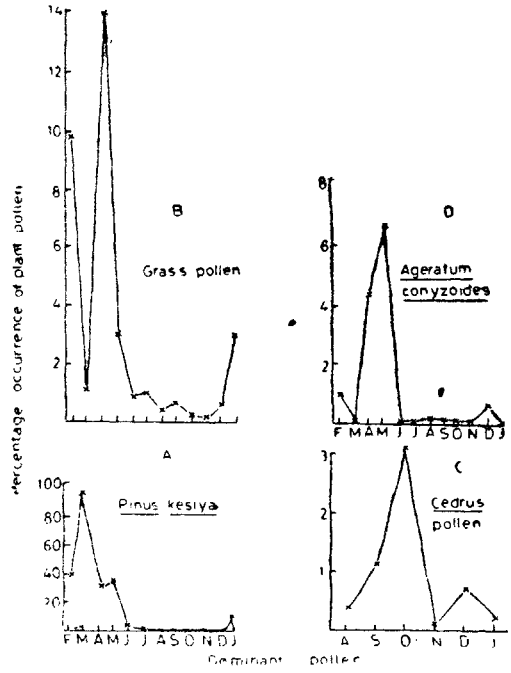


**Figure 3** Seasonal variation of air-borne pollen of some dominant species

*alnoides*, *Glochidion* spp., *Ardisia macrocarpa* and *Quercus griffithii*. November-January, being severe winter season, experience low frequency of pollen from the atmosphere and most of the plants stop flowering during this period (table 1).

*Fungal spores*: Air-borne fungal spores belonging to 35 types (72%) presented altogether a different picture in their seasonal variations. Unlike pollen grains, the fungal spores exhibited two distinct peak periods, i.e. June and September, with 18% and 24% (figure 4) respectively. *Cladosporium* sp., *Alternaria* sp., *Humicola* sp. and *Streptomyces* sp. were dominant in June, while *Cladosporium* sp., *Aspergillus* sp. and *Curvularia* sp. were so in September. Meteorological factors like heavy rainfall and high humidity during this period probably influence the prevalence of fungal spores in the atmosphere. June and September recorded the highest percentages of relative humidity (88%). With the gradual decrease in these factors from October onwards the concentrations of fungal spores also became low. The lowest concentration of the fungal spores was observed in March a relatively dry month with a higher temperature and with lowest humidity (figure 4).

Also with regard to the spore concentration of individual species, a marked seasonality was observed (figure 5). *Cladosporium* sp., *Alternaria* sp., *Torula herbarum*, *Aspergillus* sp., and *Helminthosporium* sp. occurred more or less throughout the year. *Cladosporium* sp., constituting 80–86% of total air spore (in June), was the most frequently encountered fungus, (Gregory & Hirst 1957) with highest concentration during June and July, average temperature — 23°C and relative humidity — 88%. *Cladosporium*

**Table 1** *Details of flowering period, and maximum catches of the pollen grains*

| Sl. No. | Name of species | Mode of pollination | Family | Flowering time (months) | Period of catches (months) | Density |
|---|---|---|---|---|---|---|
| 1. | *Acacia dealbata* Link. | E/A | Mimosaceae | 12-2 | 11, 12, 2 | + |
| 2. | *A. mollisema* Willd. | E | Mimosaceae | 6-10 | 7, 9 | + |
| 3. | *Abutilon* sp. | E | Malvaceae | 1-2 | 2 | + |
| 4. | *Ageratum conyzoides* Linn. | A | Asteraceae | 1-12 | 4, 5, 6, 8, 9, 10, 12 | +++ |
| 5. | *Alnus nepalensis* D. Don. | A | Betulaceae | 9-12 | 10, 11, 12, 1 | +++ |
| 6. | *Ambrosia* sp. | A | Asteraceae | 2-4 | 4, 5, 10 | ++ |
| 7. | *Ardisia macrocarpa* Wall. | E | Myrsinaceae | 6-9 | 6, 8, 9 | ++ |
| 8. | *Artemisia* sp. | A | Asteraceae | 9-12 | 6, 9 | +++ |
| 9. | *Betula alnoides* Ham. | A | Betulaceae | 8-11 | 9, 10 | +++ |
| 10. | *Cedrus deodora* Loud. | A | Pinaceae | 8-11 | 8, 9, 10, 11, 12, 1 | +++ |
| 11. | *Chrysanthemum* sp. | E | Asteraceae | 5-9 | 10 | ++ |
| 12. | *Corylopsis himalayana* Griff. | A | Hemmamelidaceae | 2-5 | 3, 5 | + |
| 13. | *Cryptomeria japonica* (Linn. F.) D. Don. | A | Taxodiaceae | 2-5 | 9 | ++ |
| 14. | *Cupressus torulosa* D. Don. | A | Cupressaceae | 7-9 | 2, 5, 6, 1 | ++ |
| 15. | *Daphne shillong* Banerji | E | Thymeleaceae | 9-10 | 2, 11 | + |
| 16. | *Docynia indica* (Wall.) Decne. | E/A | Rosaceae | 1-3 | 2 | + |
| 17. | *Duranta repens* Jacq. | E | Verbenaceae | 5-11 | 10, 12 | + |
| 18. | *Elaeagnus* sp. | E | Elaeagnaceae | 12-2 | 2, 1 | + |
| 19. | *Elaeocarpus* sp. | E | Elaeocarpaceae | 8-11 | 11 | + |
| 20. | *Eucalyptus globulus* Labill. | E | Myrtaceae | 8-12 | 1, 10, 11, 12, 1 | +++ |
| 21. | *Fagopyrum esculentum* Moench. | E | Polygonaceae | 9-11 | 9, 10, 11, 12 | +++ |
| 22. | *Gaultheria* sp. | E | Ericaceae | 4-5 | 5 | + |
| 23. | *Glochidion* sp. | E | Euphorbiaceae | | 9, 10, 11 | ++ |
| 24. | *Hypoestes triflora* R. & S. | E | Acanthaceae | 9-12 | 9 | + |
| 25. | *Ligustrum robustum* | E | Oleaceae | 5-10 | 6, 8 | ++ |
| 26. | *Lyonia ovalifolia* Wall. | E | Ericaceae | 5-10 | 7, 8, 9 | + |
| 27. | *Macropanax* sp. | E | Araliaceae | 7-9 | 9, 10, 11 | + |
| 28. | *Melodinus khasiana* Hk. f. | E | Apocynaceae | 6-10 | 7, 10 | + |
| 29. | *Myrsine semiserrata* Wall. | E | Myrsinaceae | 9-11 | 8, 9 | + |
| 30. | *Neillia thyrsiflora* D. Don. | E | Rosaceae | 5-8 | 7 | + |
| 31. | *Oenothera* sp. | E | Onagraceae | 2-4 | 5 | + |
| 32. | *Oldenlandia* sp. | E | Rubiaceae | 7-11 | 8, 11, 12 | + |
| 33. | *Osbeckia* sp. | E | Melastomaceae | 7-11 | 12 | + |
| 34. | *Parnesia* sp. | E | Saxifragaceae | 5-6 | 5 | + |
| 35. | *Pauzalzia* sp. | E | Urticaceae | 7-11 | 8 | + |

(*Contd.*)

**Table 1** (*contd.*)

| Sl No. | Name of species | Mode of pollination | Family | Flowering time (months) | Period of catches (months) | Density |
|---|---|---|---|---|---|---|
| 36. | *Photinia notoniana* Wt. & Arn. | E/A | Rosaceae | 4-5 | 5 | + |
| 37. | *Polygonum chinensis* Linn. | E | Polygonaceae | 8-2 | 1 | + |
| 38. | *P. hydropiper* Linn. | E | Polygonaceae | 5-7 | 5 | + |
| 39. | *P. punctatum* | E | Polygonaceae | 5-12 | 8, 9, 10 | + |
| 40. | *Potentilla mooniana* Wt. | E | Rosaceae | 6-10 | 9, 11 | + |
| 41. | *Pinus kesiya* Royl ex. Gordon | A | Pinaceae | 1-4 | 2, 3, 4, 5, 6 | +++ |
| 42. | *Prunus cerasoides* D. Don | E | Rosaceae | 11 | 10, 11 | ++ |
| 43. | *P. persica* Benth & Hk. f | E | Rosaceae | 3-4, 8-9 | 5, 8 | ++ |
| 44. | *Pyrus communis* Linn. | E | Rosaceae | 2-5 | 5, 7 | + |
| 45. | *Quercus griffithii* Hk. f & Th. | A | Fagaceae | 7-8 | 5, 6, 7, 8 | + |
| 46. | *Ranunculus* sp. | E | Ranunculaceae | 7-9 | 9, 10, 11 | + |
| 47. | *Rhododendron arboreum* Sm. | E | Ericaceae | 3-4 | 4 | + |
| 48. | *Rhus semialata* Murr. | A | Anacardiaceae | 5-7 | 5 | + |
| 49. | *Rubus ellipticus* Sm. | E | Rosaceae | 3-5 | 4, 5, 6 | + |
| 50. | *R. micropetalus* Gard. | E | Rosaceae | 8-10 | 6, 8, 9 | + |
| 51. | *Rubia cordifolia* Linn. | E | Rubiaceae | 8-9 | 8, 9, 10 | + |
| 52. | *Schima wallichii* Chois. | E | Theaceae | 5-8 | 5, 6, 7 | ++ |
| 53. | *Strobilanthes* sp. | E | Acathaceae | 9-11 | 7, 8, 10, 11, 1 | + |
| 54. | *Symplocus spicata* Roxb. | E | Symplocaceae | 6-8 | 6, 8, 10 | ++ |
| 55. | *Trifolium repens* Linn. | E | Papilionaceae | 1-4 | 1, 2 | + |
| 56. | *Vaccinium* sp. | E | Vacciniaceae | | 10 | + |
| 57. | *Viburnum* sp. | E | Caprifoliaceae | 4-8 | 5, 6, 7, 8, 9, 10 | +++ |
| 58. | *Zea mays* | A | Poaceae | 8 | 8 | ++ |
| 59. | Grass pollen | A | — | — | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1 | +++ |
| 60. | Malvaceae pollen | E | — | — | 2, 4, 5, 6, 7, 8, 9, 10, 11, 1 | +++ |
| 61. | Convolvulaceae pollen | E | — | — | 5 | + |
| 62. | Asteraceae pollen | A | — | — | 2, 4, 6, 9, 10, 11 | +++ |
| 63. | Urticaceae pollen | A | — | — | 8 | + |

*1–12 months of the year (1 stands for January and 12 for December)
+ = Low; ++ = High; +++ = Maximum
*A*, Anemophilous; and *E*, Entomophilous pollen

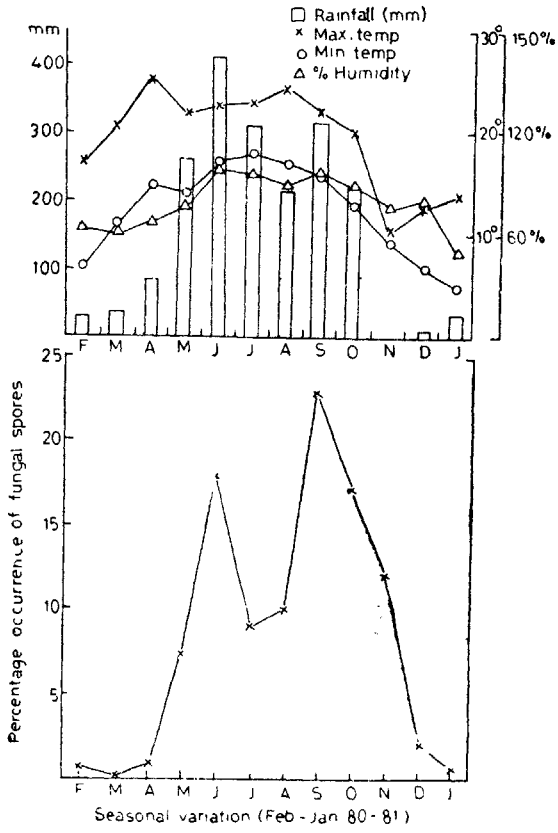


**Figure 4** Seasonal variation of air-borne fungal flora in relation to meteorological conditions

spp. has been reported as a dominant air-borne mold in culture plate studies by some workers (Barat & Nandi 1966). Similar effect of seasonal fluctuations on the occurrence of *Cladosporium* spp. has been reported by different workers of Eastern and North Eastern India (Barat & Nandy 1966, Chakraborty & Nandi 1972, Singh et al. 1981).

*Alternaria* sp., which is known to be responsible for causing allergenic respiratory problems as well as diseases in various crops plants (Gregory 1973, Sandhu et al. 1964), exhibited a marked phenological periodicity—the highest concentration (i.e. 5%) in February (when the temperature was 20–24°C and relative humidity—60–80%) and next highest during April and August (i.e. 4 & 3% respectively, figure 5b). *Torula herbarum* (11.35%), *Helminthosporium* sp. (3%) and *Aspergillus* sp. (3.40%), were some other dominant air-borne fungi in the area.

Out of 35 types of fungi, *Cladosporium* sp., *Alternaria* sp., *Aspergillus* sp., *Curvularia* sp., and *Helminthosporium* sp. were present throughout the year, while *Epicoccum* sp., *Mucor* sp., *Trichoderma* sp., *Streptomyces* sp., *Pithomyces* sp., *Stigmatia* sp., and *Chaetomium* sp., occurred during summer; *Pillularia* sp., *Papularia* sp., *Sardania* sp., *Absidia* sp., *Brachysporiella* sp., *Stemphyllum* sp., *Pseudotorula* sp., *Venturia* sp., and

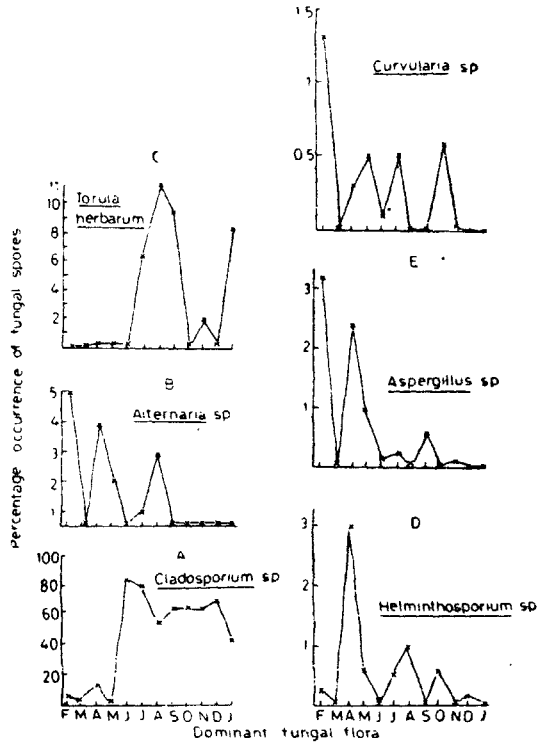


**Figure 5** Seasonal variation of some dominant fungal spores

*Urocystis* sp. during winter, and *Penicillium* sp., *Boletus* sp., *Humicola* sp., *Bipolaris* sp., and *Arthrinium* sp. during rainy season (table 2).

Thus, of the total air-spora, pollen grains constituted of 22%, fungal spores 72% and other components of biological origin 6%.

**Table 2** *Details of fungal spore type, periods of catches and densities*

| S. No. | Name of species | Months of collection | Densities |
|---|---|---|---|
| 1. | *Absidia* sp. | 8, 9 | + |
| 2. | *Alternaria* sp. | 2, 3, 4, 5, 6, 8, 9, 10, 12, 1 | +++ |
| 3. | *Arthinium* sp. | 9, 10 | + |
| 4. | *Aspergillus* sp. | 2, 4, 5, 6, 7, 9, 11 | +++ |
| 5. | *Asterosporium* sp. | 7 | + |
| 6. | *Bipolaris* sp. | 8, 9, 10, 11, 12 | ++ |
| 7. | *Boletus* sp. | 8 | + |
| 8. | *Brachysporiella* sp. | 8, 11 | + |
| 9. | *Cercospora* sp. | 9 | + |
| 10. | *Chaetomium* sp. | 6, 7 | + |
| 11. | *Cladosporium* sp. | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1 | +++ |
| 12. | *Curvularia* sp. | 2, 4, 5, 6, 7, 8, 9, 10, 11 | +++ |
| 13. | *Epicoccum* sp. | 2, 4, 5, 8, 9, 10, 11, 1 | ++ |
| 14. | *Helminthosporium* sp. | 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 | +++ |
| 15. | *Humicola* sp. | 4, 5, 6, 7, 8, 9 | ++ |
| 16. | *Mucor* sp. | 2, 4, 5, 6, 7, 8 | ++ |
| 17. | *Nigrospora* sp. | 11 | + |
| 18. | *Papularia* sp. | 8, 9, 11 | + |
| 19. | *Penicillium* sp. | 8, 9, 10 | + |
| 20. | *Pithomyces* sp. | 5 | + |
| 21. | *Pleospora* sp. | 2, 8, 9, 10, 11 | ++ |
| 22. | *Pseudo-torula* sp. | 10, 11 | + |
| 23. | *Pullularia* sp. | 8, 9, 10, 11 | + |
| 24. | *Sardaria* sp. | 5, 10 | + |
| 25. | *Stemphyllium* sp. | 2, 11 | + |
| 26. | *Stigmatea* sp. | 6, 7 | + |
| 27. | *Streptomyces* sp. | 5, 6 | + |
| 28. | *Tetraploa* sp. | 5, 6, 7, 8 | + |
| 29. | *Torula herbarum* (Pers.) | 4, 6, 7, 8, 9, 10, 11, 12, 1 | +++ |
| 30. | *Trichoderma* sp. | 2, 4, 7, 8 | + |
| 31. | *Triposporium* sp. | 2 | + |
| 32. | *Urocystis* sp. | 9 | + |
| 33. | *Ustilago* sp. | 8 | + |
| 34. | *Venturia* sp. | 9 | + |
| 35. | Unientified basidiospore | 8 | + |

1–12 months of the year (1 stands for January and 12 for December)
+, low; ++, high; +++, maximum

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