*EPIDEMIOLOGY OF TEA BLISTER BLIGHT (*EXOBASIDIUM VEXANS*)

II—THE DIURNAL AND SEASONAL PERIODICITY OF SPORES IN THE AIR OVER A TEA ESTATE

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Using an automatic volumetric spore trap for sampling air at 1 m. above ground in a field at the Tea Research Institute, Talawakele, the diurnal and seasonal periodicity of spores of *Exobasidium vexans* Massee were followed.

The seasonal periodicity was not very marked. The highest catches were recorded in May and June and again in November, coincident with the two monsoons (the South-West and the North-East) when the spores reached mean concentrations of 10,500 and 9600/m.^{3} air, respectively. The lowest catch (2000/m.^{3}) was recorded in March.

Two-hourly concentrations obtained on 24 days in July indicated a very pronounced diurnal rhythm in the spore content. The highest concentration was reached between midnight and 04.00 hr. and in this respect *E. vexans* seems to resemble several other Basidiomycetes which show a similar nocturnal pattern. The diurnal periodicity could, however, be greatly altered by weather conditions. For instance, a heavy thunderstorm at approximately 13.00 hr. on 25 and 26 October, resulted in two peak catches on those 2 days, high concentrations occurring in the first and second hours after the onset of rain, and again in the early hours of the morning. Prolonged rain, on the other hand, generally resulted in a drop in the mean daily catch.

For a clear understanding of the epidemiology of a disease, it is often necessary to have some knowledge of the spore dispersal of the pathogen and its relationship to time and weather. Such knowledge may sometimes also assist in the formulation of forecasting and control methods. Considerable work of this kind has been carried out by Hirst (1952), Gregory (1951) and others at Rothamsted in England, and by Pady (1957) and his associates in the United States. These workers have contributed much to our knowledge about the composition and fluctuation of the air spora of temperate climates, but detailed information concerning the air spora of tropical climates is still very meagre.

This paper deals briefly with observations made on the dispersal of spores of *Exobasidium vexans*. Mature blisters discharge spores which are wind-borne and form the main source of inoculum for fresh infections. Spores are two-celled, hyaline and elliptical in shape and are easily recognizable under the microscope (Figure 1).

Materials and Methods

Spore trapping was carried out using an automatic, volumetric trap of the Casella type (Hirst 1952), located in a field adjoining the laboratory at St Coombs. The trap orifice was about a metre from the ground and was level with the tea-plucking table. Slides were prepared and mounted as described by Hirst, and were changed daily at 9.00 hr. (I.S.T.). The trap was in continuous operation for over

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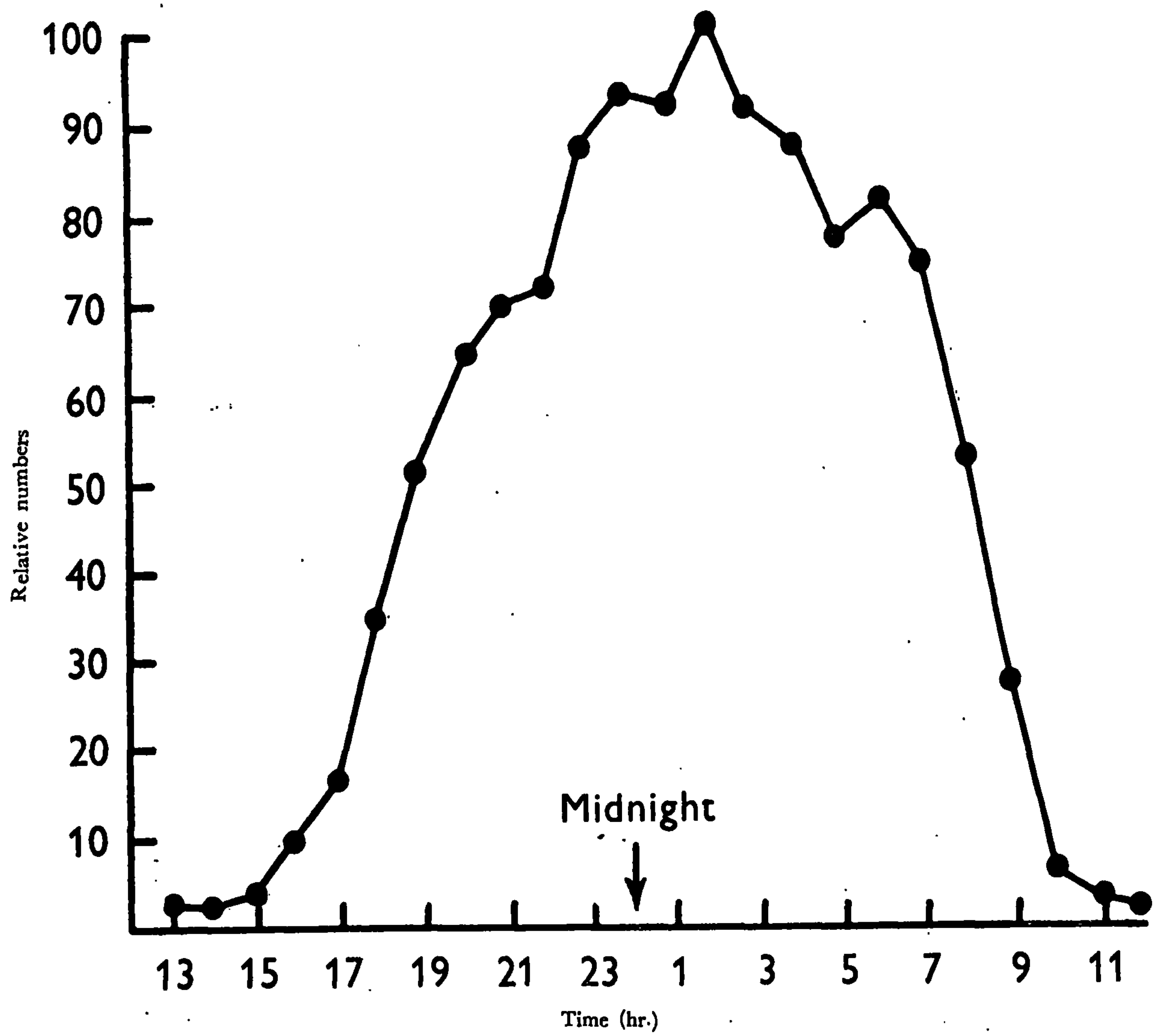


FIGURE 2—*Mean diurnal periodicity of spores of* E. vexans *(8-31 July)*

2 years and the total catch was enumerated daily, except for short periods when 1 – 2 hourly catches were recorded separately. Catches consisted predominantly of basidiospores of *E. vexans* (over 90%) ; other spores included several hyaline and coloured basidiospores, few ascospores, and spores of Fungi Imperfecti. Spores of mosses and ferns, and pollen were comparatively rare.

Results

Diurnal periodicity

The most striking observation made in this study was the marked diurnal periodicity in the dispersal of spores of *E. vexans*. This is shown in Figure 2 where the hourly estimates for 8–31 July, expressed as percentages of the maximum, are plotted against time. The highest concentration of spores was reached in the early hours of the morning and the lowest at about mid-day, when numbers sometimes dropped to zero. An interesting feature is that the rise from a low value to the maximum and the fall from the maximum to low value are both gradual, unlike those in many other organisms where the rise from low to maximum is normally rapid, but the fall relatively slow.

The highest hourly concentration observed during the trapping period was approximately 58,000 spores/$m.^3$ air and was recorded on several occasions in the early hours of the morning ; the lowest was, of course, 0.

E. vexans clearly has a nocturnal pattern of spore dispersal, and thus resemble other ballistospore producers, which exhibit the same phenomenon.

Effect of heavy afternoon thunderstorms

Heavy afternoon thunderstorms seem to increase the spore concentration either during or immediately after the rain. For example, a heavy thunderstorm at approximately 13.00 hr. on 25 and 26 October resulted in two peak catches on those 2 days, high concentrations occurring soon after the onset of the rain and again in the early hours of the morning (Figure 3).

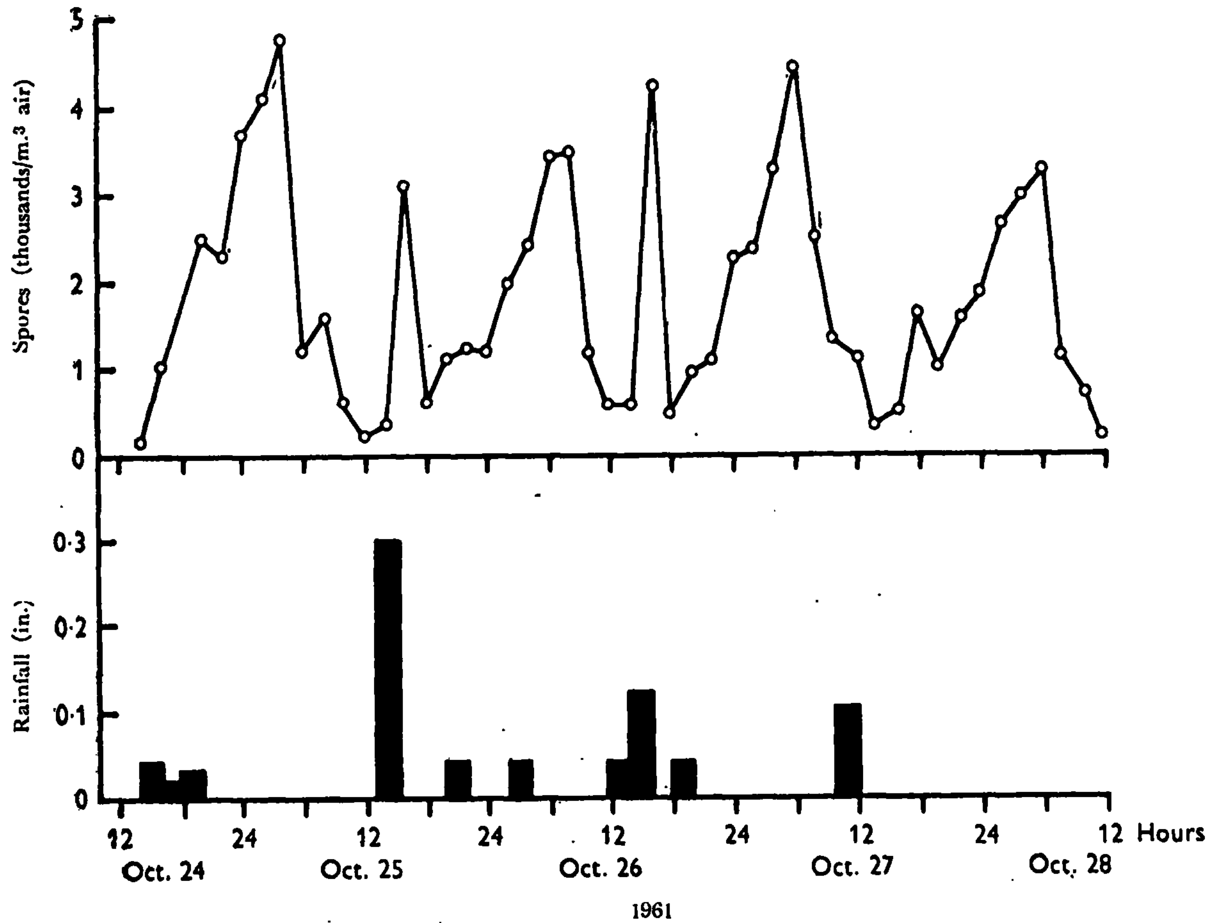


FIGURE 3—*Changes in spore concentration of* E. vexans *due to afternoon thunderstorms*

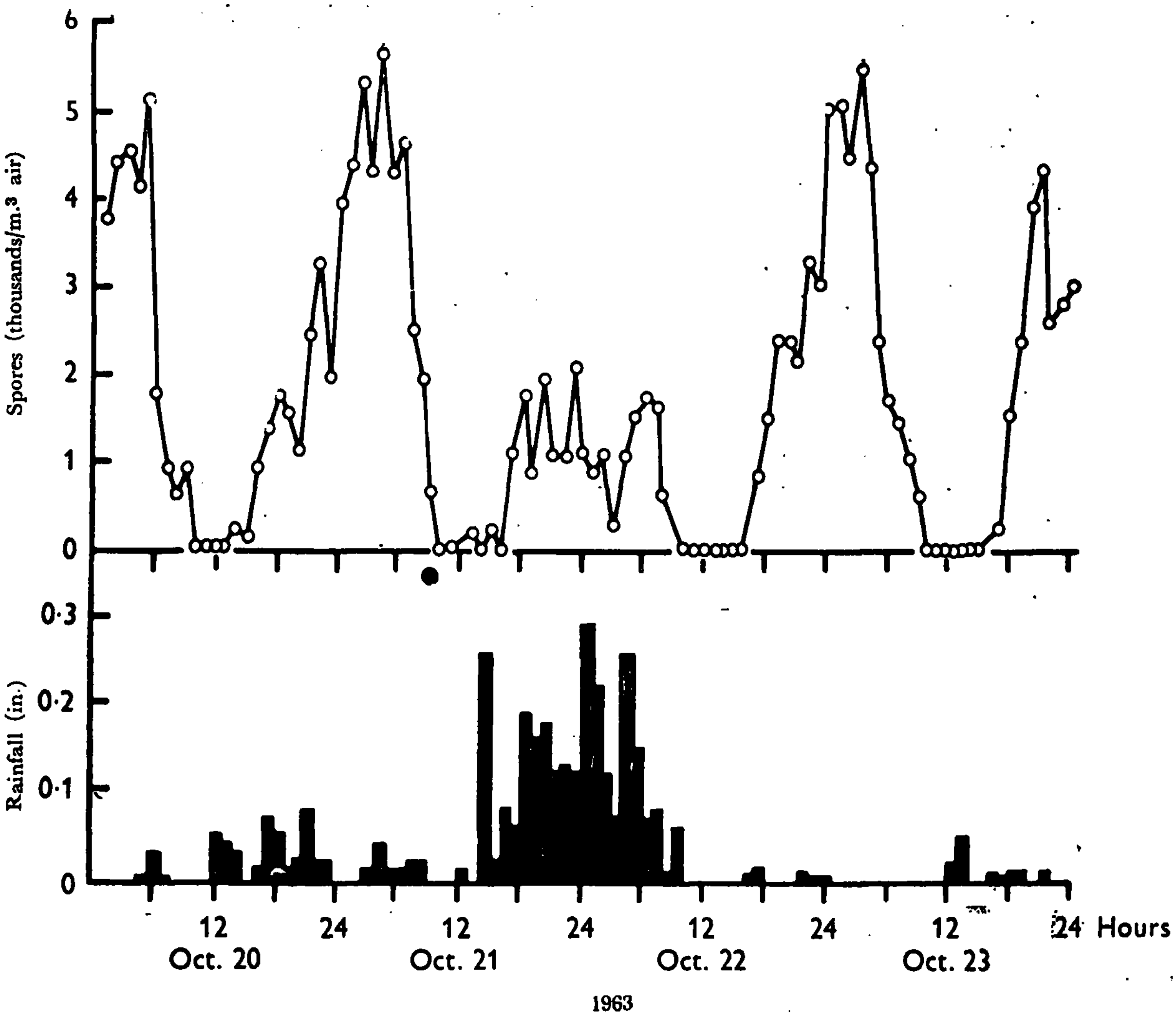
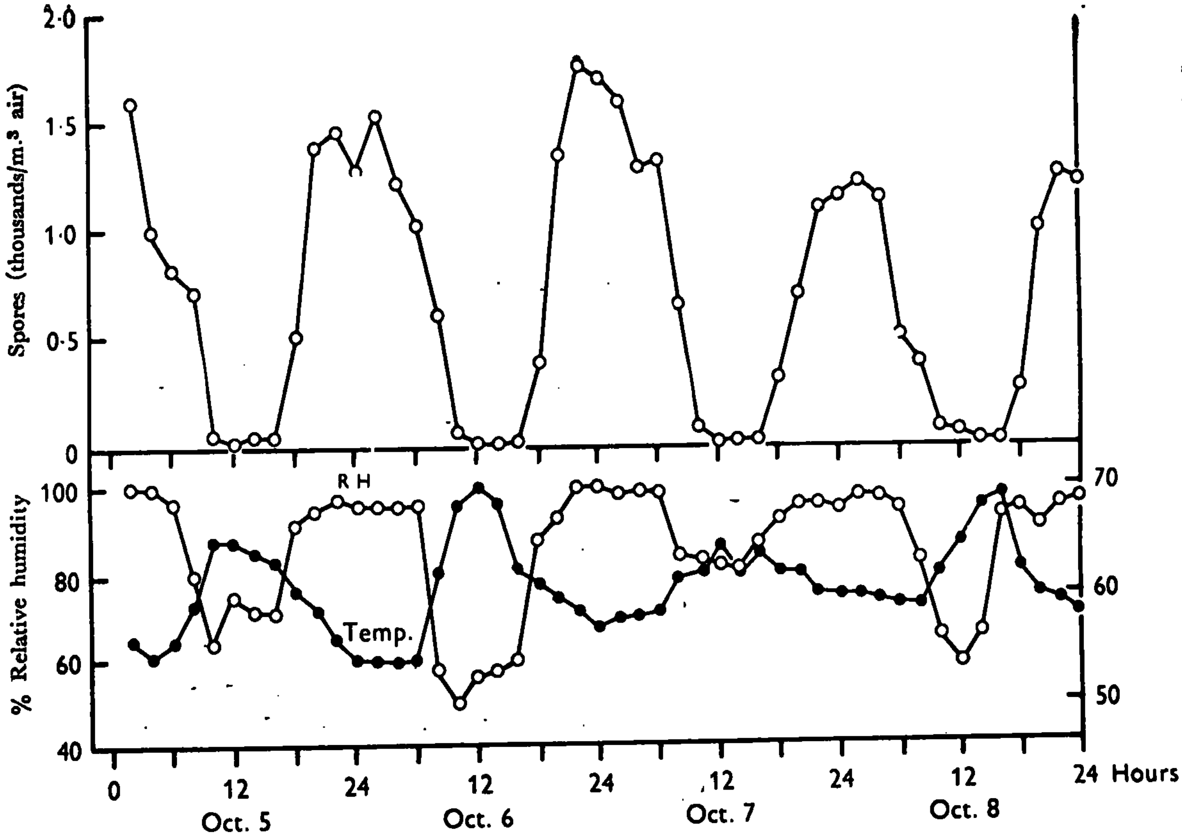


FIGURE 4—*Changes in spore concentration of* E. vexans *due to prolonged rain*

Hirst (1953) apparently is the only other worker who has made a similar observation. He found that the number of *Cladosporium* spores increased from 36,000/m.³ to 55,000/m.³ during the first hour after a thunderstorm; he also observed that the number of ascospores of *Venturia inaequalis* increased during the second and third hours after heavy rain.

Effect of prolonged rain

While the effect of afternoon thunderstorms is to cause a transient increase in the spore concentration, the effect of prolonged heavy rain seems to be different. If there is continuous heavy rain of several hours duration, there is generally a drop in the daily catch. On the other hand, a steady drizzle does not seem to affect appreciably the total catch, although it tended to interfere with the daily rhythm to a certain degree (Figure 4). Hirst (1953) has shown that pollen, spores of *Cladosporium*, *Erysiphe*, *Alternaria*, rusts and smuts (mainly components of daytime 'dry air spora') are mostly removed by prolonged rain and are replaced by 'damp air spora' (mainly ascospores and basidiospores). But here we have an instance where a component of the 'damp air spora' is suppressed by heavy rain.



1963

FIGURE 5—*The relation between spore concentration* (E. vexans) *and relative humidity and temperature*

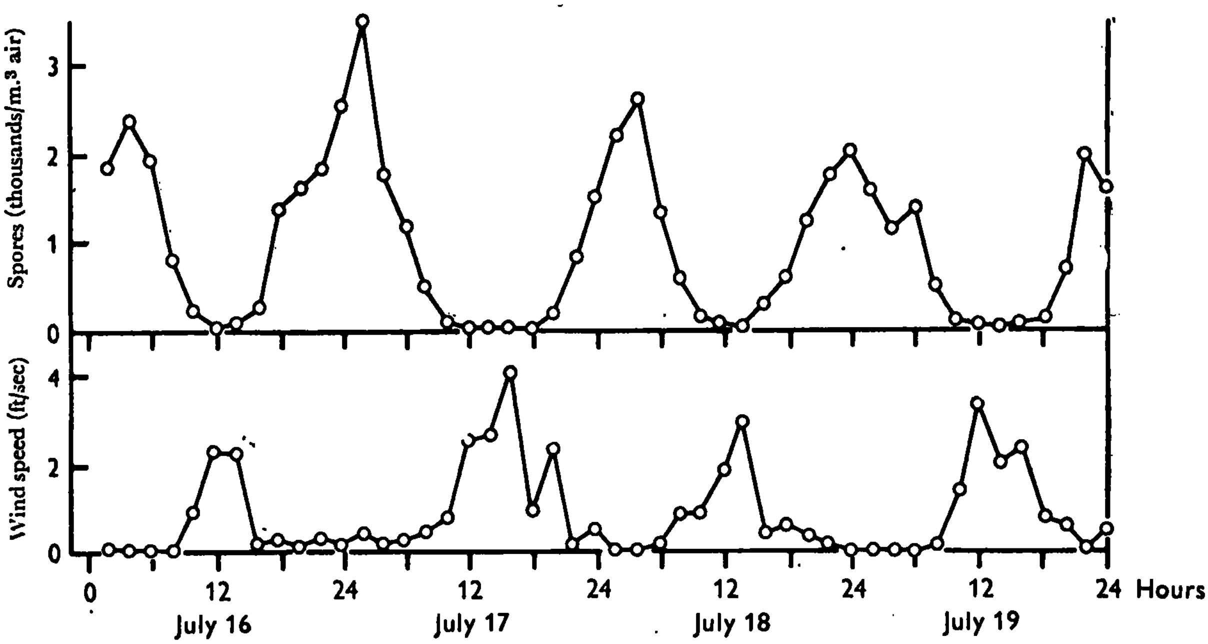


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FIGURE 6—*The relation between spore concentration* (E. vexans) *and wind speed*

Effects of relative humidity, temperature and wind speed

The periodicity curves shown in Figures 5 and 6 illustrate these effects very distinctly. Here we have chosen periods with little disturbance by rainfall. It is clear from the first of these curves that there is a strong positive correlation between spore concentration and R.H. (r = 0.812) and an equally strong negative correlation between spore concentration and temperature (r = −0.805). The second curve indicates a negative correlation between wind speed and spore concentration; although this correlation is not as high as the first two, it is still very highly significant (r = −0.651). The close relationship between high R.H. and high spore concentration is also evident from Figure 7 where spore concentration is plotted against the number of hours with R.H. greater than 95%. The relationship with temperature and R.H. was not unexpected, in that it is typical of most components of damp weather air spora. The correlation with wind speed appears at first sight to be a little curious, because one would have expected the concentration of spores to increase with a rise in wind speed. This would have been the case if the effect was purely a physical one ; here it appears as though wind is exerting its effect indirectly by its influence on the plant and/or by its influence on R.H. Also the magnitude of the wind speeds recorded were so small that it is hardly possible to visualize a direct physical effect. Hamilton (1957) also noted that increased wind significantly decreased the concentration of some basidiospores as well as other spores.

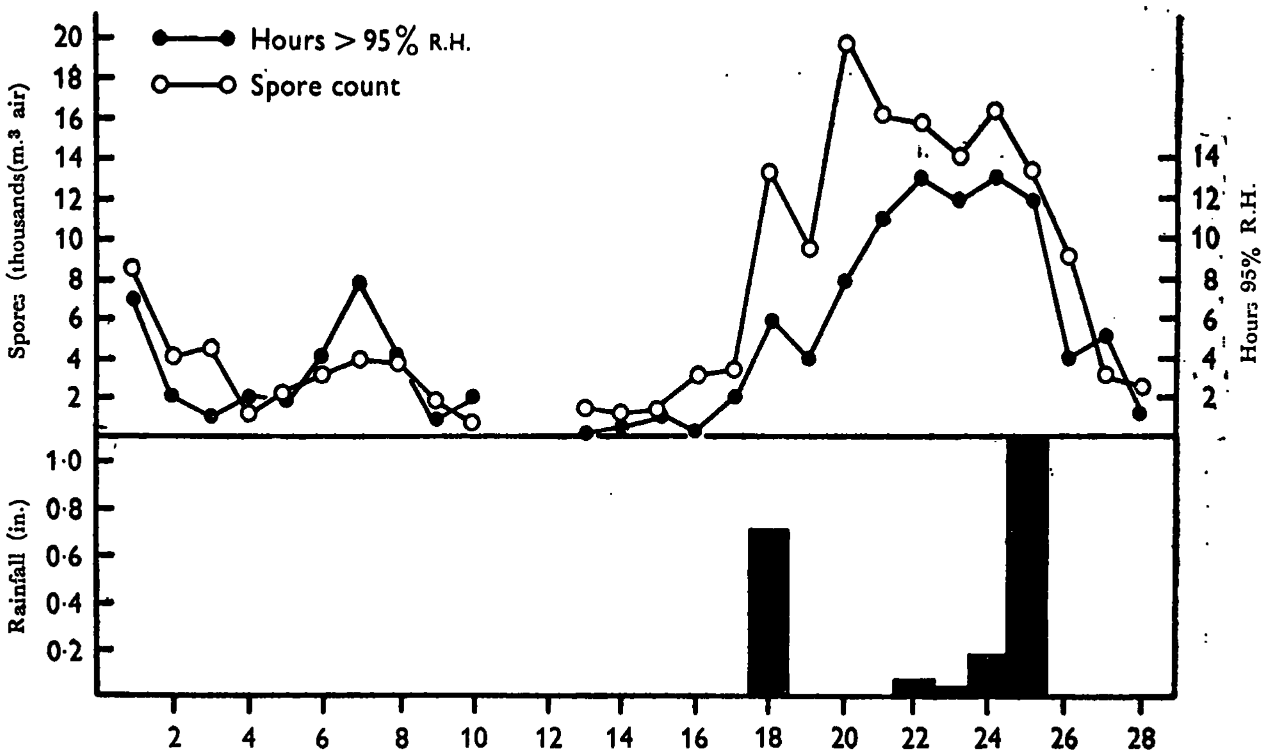

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FIGURE 7—*The relation between spore concentration* (E. vexans) *and relative humidity*

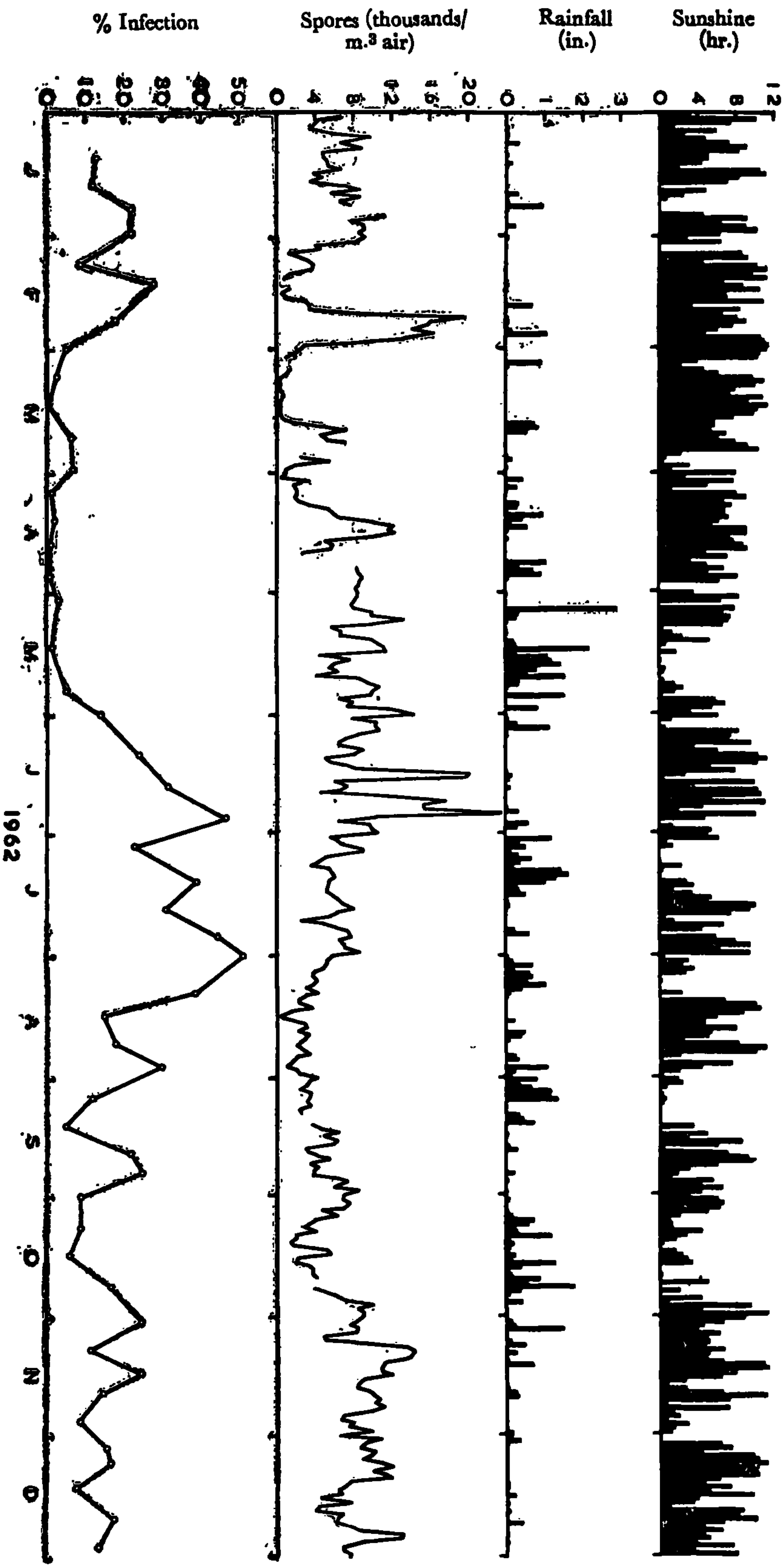

FIGURE 8—*Seasonal variation in spore concentration and its relationship to weather and field infestation*

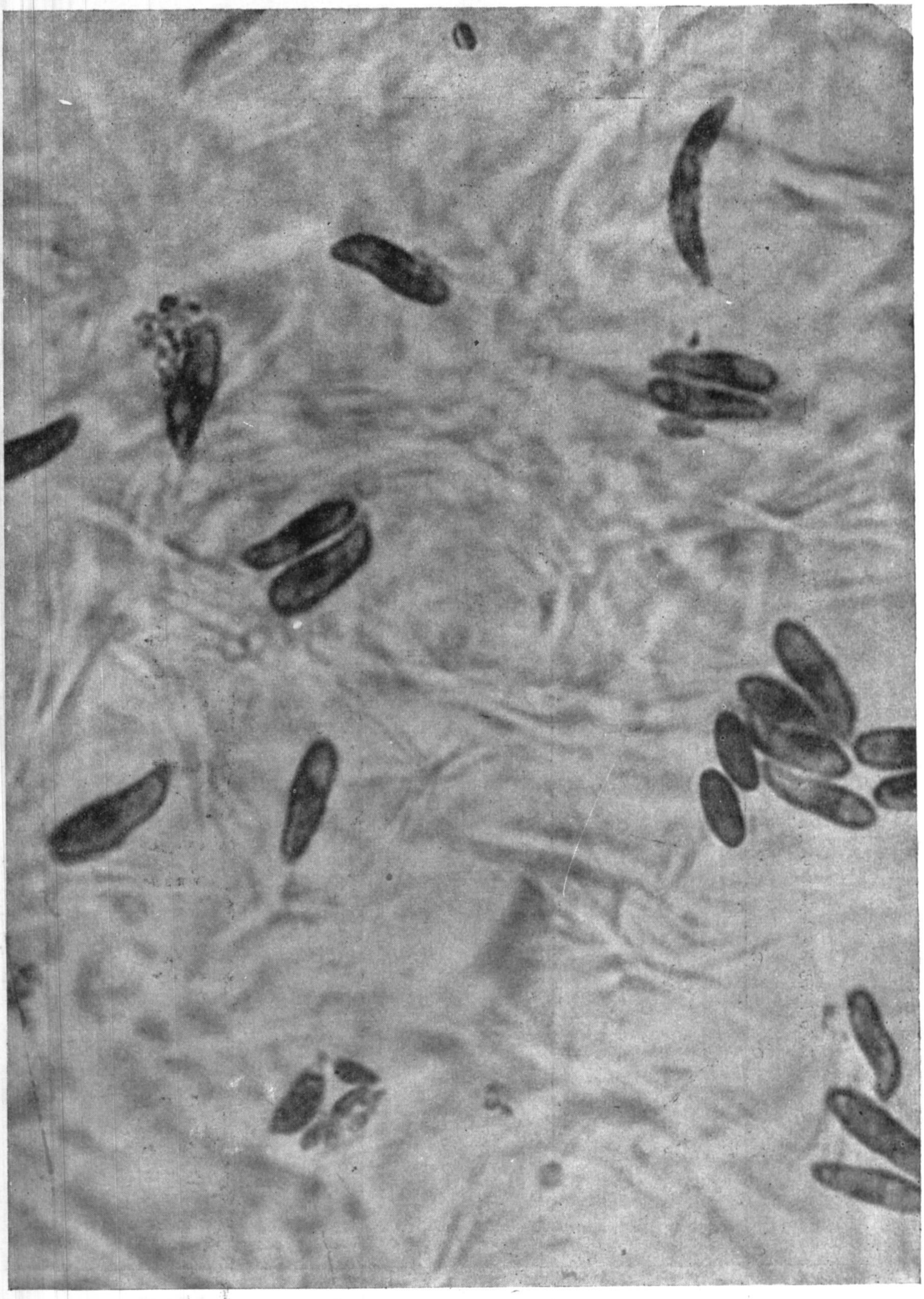

FIGURE 1—*A typical photomicrograph of a slide showing several basidiospores of* E. **vexans**

Seasonal periodicity

Figure 8 shows the seasonal variations in the spore content and its relationship to weather conditions, particularly rainfall and sunshine, and field infestation.

High catches were recorded in May and June, coincident with the South-West monsoon, when the spores reached a mean daily concentration of 10,000/m.^{3} air, and again in November, coincident with the North-East monsoon, when the mean concentration was about 9600/m.^{3} air. The lowest monthly estimate was in March, when the concentration dropped to 2000 spores/m.^{3} air. The highest daily catch recorded was 25,000/m.^{3} on 25 June and the lowest was 22/m.^{3} on 14 March.

A significant observation in this study, however, was the presence of a fairly large number of spores even during the comparatively drier months of February, March and April, when field infestation is generally low and spraying is discontinued.

Discussion

E. vexans exhibits a pronounced diurnal rhythm in its spore dispersal, but changes in weather, particularly rainfall, can modify this pattern greatly. The cause of these diurnal fluctuations are undoubtedly complex and it is difficult to assign to any particular weather factor a predominant role because those factors are themselves inter-related.

In any case, it appears as though the high night catches are due to the high R.H. prevailing during this time, and possibly dew formation. High night catches should not always be interpreted as due to increased spore discharge at this time, because we do not yet know whether the observed duirnal rhythm reflects a similar pattern in spore production. It is possible that spore emission is relatively constant during the 24 hr., but that the spore cloud is considerably diluted during the day due to atmospheric disturbances while at night, when effects of turbulence are usually small, spores might remain concentrated near the ground.

The effect of afternoon thunderstorms again is difficult to explain ; what probably happens is that there is a transient increase in R.H. resulting in a sudden rise in spore numbers. The drop in catch due to prolonged rain is probably due to removal of spores from the air and/or a suppression of spore production.

Changes in the spore concentration at different times of the year seem to reflect changes in the weather. As expected, high catches were recorded during the monsoon months. Surprisingly, appreciable numbers were also recorded during the drier months. The high concentrations observed in February accompanied by a fairly high disease intensity could probably be accounted for by the heavy dew formation that occurs during this time.

It appears from these observations that there are always sufficient spores in the atmosphere for a serious outbreak of the disease to occur any time when conditions become favourable for infection. This is probably why the build-up of the disease with the onset of the monsoon is always rapid. The relationship between spore concentration in the air and field infestation has been dealt with in an earlier communication (Kerr & Shanmuganathan 1966).

Admittedly these studies only indicate some of the factors or interactions of factors that control the fluctuation in the spore content and should be supported by experiments carried out under controlled environmental conditions in the laboratory before the effects of the different conditions can be fully assessed. Moreover, these same factors can also have a profound effect on the mechanism of spore liberation, about which we know very little.

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