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CONCENTRATIONS OF BASIDIOSPORES OF THE
DRY ROT FUNGUS (*MERULIUS LACRYMANS*)
IN THE AIR OF BUILDINGS

By

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INTRODUCTION

There is little information on the total air spora (air borne spore flora) inside buildings. Most previous studies have measured spore deposition under gravity on sterile media which selectively favour the easily growing moulds. Gregory and Hirst (3, 4) using suction traps in the open air have shown that many spore types occur besides those of the moulds. At the suggestion of Dr. K. Maunsell, Institute of Laryngology and Otology, London, in the autumn of 1952 we measured the concentration of basidiospores in the air of buildings affected by dry rot, using recently developed suction traps.

The dry rot fungus *Merulius lacrymans* (Wulf.) Fr., is considered by Cartwright and Findlay (1) to be the fungus most destructive of timber in buildings in Europe. When fruit-bodies occur in affected buildings the many basidiospores that are liberated show as a reddish brown deposit on floors and other surfaces. This great production of spores is important both from its part in spreading the fungus and for its effect after inhalation on the health of allergic subjects. Frankland and Hay (2) have shown that in a group of al-

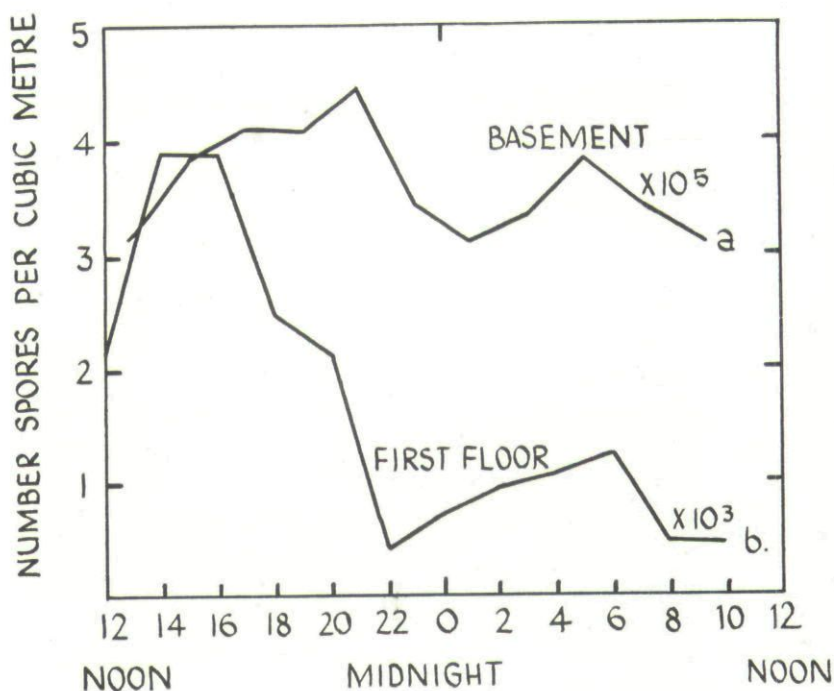
lergic patients some were sensitive to extracts of the spores, and that the inhalation of the spores of *Merulius lacrymans* by a known sensitive patient produced asthmatic symptoms at any time.

Two types of suction trap were used in different experiments, the Cascade Impactor (6) and the Automatic Volumetric Spore Trap (5). In both the air was sucked through the orifices by a small vacuum pump adjusted to give a suction rate of 10 litres per min., the air flow being measured by a "Rotameter". In the Cascade Impactor (Casella's model), which was fitted with a bell shaped mouth as recommended for sampling in comparatively still air, the air is accelerated in stages and the spora is fractionated by size on a set of four stationary slides. In the Automatic Volumetric Spore Trap the spores are impacted on to a slowly moving slide so that the time of deposition can be determined within ± 1 hour. In both traps the slides were coated with "Vaseline". Inside the buildings the traps were placed well clear of walls, furniture, etc. The height of the orifices from the floor, which is not believed to be critical, varied from 2 to 6 ft.

HOUSE IN LONDON

The first tests were made in a large dwelling house, about 130 years old, which had been damaged by bombing about ten years previously and the roof inadequately repaired. The lower parts of the house, especially the cellars and woodwork on the ground floor, were badly affected by dry rot. People were still living in the house in September 1952 when our first tests were made. Mycelial plates were present on the walls of ground floor rooms, but the characteristic sporulating fruit-bodies were seen only in the cellar.

On 6 September two samples were taken with the Cascade Impactor in a large ground floor room measuring approximately 18×40 ft. This room was damp and not used, and the windows were kept closed. The first sample was taken



from 16.00–17.00 hr. G.M.T. and contained 26,300 dry rot spores /m³. The second sample taken from 17.00–20.00 hr. contained 26,000 spores /m³. The deposit obtained consisted almost exclusively of spores of *Merulius lacrymans*. In over 2000 spores counted the only other types seen were 3 spores of *Cladosporium*, 3 or 4 of *Ustilago*, and 1 *Polythrincium*. Seventy per cent. of the spores were found on the 2nd. Impactor slide, the other 30% on the 3rd. slide. The 4th. slide contained only the dense smoke trace which we find whenever we have sampled with the Cascade Impactor in London or the Home Counties.

The house had been condemned by the local authority, and after it had been vacated it was again visited on 8 November 1952, when two 1-hour and one half-hour samples were taken with the Cascade Impactor. On this occasion the

ground floor room tested on the previous visit gave 16,400 spores /m³; a room on the first floor gave 16,100 spores /m³; and the cellar, where actively sporing fruit-bodies were still evident gave 79,500 spores /m³. In the cellar 88% of the basidiospores were on the 2nd. Impactor slide, but in the other rooms only 70% occurred on the 2nd. slide as on the previous visit.

COUNTRY MANSION

A sixteenth Century house, which had been disused as a residence for about 40 years, was occupied by the Army during the second world war. The interior of the house had suffered from damp largely because lead had recently been removed from the roof.

On 15 November 1952 the Automatic Volumetric Spore Trap was installed in a cellar which had about 4 or 5 square feet of active dry rot fruit-body on the vaulted roof. Floor and shelves were covered with a brown deposit of spores. During the test from 11.45 hr. 15 November to 10.20 hr. 16 November, the temperature was steady at 8°C, and the relative humidity varied from 90% at noon to over 95% at 16.00 to 20.00 hr.

The trap slide when removed was uniformly coated with a rusty brown spore deposit. The average concentration during the 24 hours was estimated at 360,000 spores /m³, and so far as could be seen consisted exclusively of basidiospores of *Merulius lacrymans*. The 2 hourly concentrations varied from 3.2×10^5 to 4.5×10^5 during the sampling period (Fig. 1, a).

On 16 November the trap was moved to an exposed and draughty corridor on the first floor. There were two small dry rot fruit bodies outside the door and one inside the passage. The temperature varied during the 24 hr. run from 3.5° to 4.5°C, and the relative humidity from 73 to 80%. The mean basidiospore concentration was estimated at 1,630 spores /m³ (Fig. 1, b), and the two-hourly concentrations fluctuated between 0.4×10^3 and 3.9×10^3 spores m³-a

greater range than that recorded for the basement the previous day. (Fig. 1, b).

During this second test from 11.05 on 16 November to 10.45 hr. on 17 November, a horizontal slide trap was exposed in the same room. The observed deposit of 14 spores/cm² in 24 hours from a spore cloud of concentration 1,630 spores/m³ corresponds to a spore fall rate of 0.097 cm/sec. This agrees excellently with the expected value of approximately 0.1 cm/sec. for a sphere 7 μ diam. of unit density (the spores are approximately $9.5 \times 5.5 \mu$). Wind-tunnel experiments have shown that a horizontal slide trap gives nearly the expected value for sedimentation under gravity at wind speeds of 0.5 m/sec., but that at higher wind speeds other factors introduce errors.

COUNTRY COTTAGE

For comparison with buildings affected with dry rot one sample was taken between 11.30 and 12.30 hr. on 13 November 1952 in a furnished ground-floor living room in a cottage on Harpenden Common. The house was unoccupied during the daytime and had not been swept during the 48 hours before the test. The Cascade Impactor was used to fractionate the particles trapped. The catch on the 4 Impactor slides was as follows.

- Stage 1. A few hairs and other fibres, some from carpet.
2. Some epithelial cells and mineral particles. One chain of 4 fungus spores (?*Penicillium*), and one other doubtful spore.
3. Very small amorphous particles, no spores.
4. The usual smoke deposit.

DISCUSSION

In the few buildings tested very few spores characteristic of the out-door air spora were observed. Two of the buildings

were chosen because they had dry rot, and basidiospores of *Merulius lacrymans* were abundant. The concentrations varied greatly in different parts of the same building. There is no evidence of a particularly high concentration at the start of a 24-hour run, and it is therefore probable that, once the spores are deposited, they are not easily re-suspended by casual movement and that the spores found in the air were freshly liberated. An attempt can be made to estimate the approximate rate of spore production at 8°C from the fruit-bodies in the cellar in the country mansion. The area of active fruit body on the ceiling was estimated at about 0.5 m², and the floor surface of the cellar was estimated at 50 m². It is assumed that spores once deposited did not re-suspend, that they fell in still air at 0.1 cm/sec., and that small convection currents sufficed to maintain a uniform concentration in a horizontal plane. The number of spores liberated per second from 0.5 m² of fruit body must have been sufficient to keep a layer of air of volume 0.1 cm. $\times$ 50 m² at a concentration of 360,000 spores /m³. This corresponds to the production of 3000 spores per square centimetre per day.

When the automatic trap was used for 24-hour periods, fluctuations in spore concentration were recorded, but there are too many possible interpretations and too little evidence of regularity in the small amount of data to justify any conclusions as to the causes of such fluctuations.

Evidently spores can travel in slow convection currents from rooms and cavities containing a sporulating fruit-body to distant parts of the house. The distribution of spores in the various fractions of the Cascade Impactor suggests that those caught in the basement were on the average heavier than those caught on the ground floor and first floor of the London house. In the still air of a closed house, deposition on a horizontal slide may give a reliable estimate of the spore concentration of *Merulius lacrymans*. Assuming a rate of fall in still air of 0.1 cm/sec., a deposit of 1 spore /cm² in 24 hours corresponds to a concentration of about 110 spores /m³.

The concentration of basidiospores observed in the cellars

of the two houses with dry rot was very much higher than that of coloured basidiospores in the air of rural districts, though we have sometimes found similar concentrations of minute hyaline basidiospores in such districts at night.

SUMMARY

The spore content of the air in two buildings affected by *Merulius lacrymans* was estimated during autumn 1952 using power-operated suction traps. In a condemned bomb-damaged house in London, concentrations ranged from 79,500 spores per cubic metre in a cellar with active fruit-bodies to 16,000 per cubic metre on a first floor room without fruit-bodies. In a country house concentrations ranged from 360,000 spores per cubic metre in a cellar to 1,630 spores per cubic metre in a first-floor corridor, both with active fruit-bodies. The undisturbed air in an old unaffected cottage in Harpenden contained no spores of *Merulius lacrymans* and less than 10 spores per cubic metre of any kind.

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