

Aerobiological studies based in Derby

I. A simplified automatic volumetric spore trap

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Summary

A simplified version of the Hirst automatic volumetric spore trap has been developed in Derby for aerobiological studies. In comparative trials, the numbers of spores retained by the Morrow Brown trap were similar in the case of larger spores such as *Alternaria* (102%), rather higher in the case of grass pollen (136%) and considerably higher (166–201%) for very small spores such as *Sporobolomyces* and *Tilletiopsis*. Impaction efficiency has been improved by using a narrower slit. The trap designed in Derby is simple to produce and presents advantages in design over the Hirst version.

Introduction

Research into the causes and treatment of seasonal allergic disease necessitates continuous air sampling, to monitor pollen and spore counts on a daily basis. The first attempt to do this was by Charles Blackley of Manchester, who devised simple gravity methods of pollen counting, and published pollen counts in his classic monograph (1873) which are remarkably similar to those obtained today.

Little work of this kind was carried out for some 60 years, until very similar methods were used in the U.S.A. in the 1930s, a standard gravity sampling device being described by Durham (1946), and later by Hyde (1950), in England and Wales. However, all gravity methods of sampling are inherently inaccurate, especially in the case of smaller spores (Gregory, 1973), and all this basic research suffered from the distorting effects of wind speed, direction and turbulence, and the favouring of larger particles.

The development of the continuously operated automatic volumetric spore trap by Hirst (1952) was, therefore, a great step forward for aerobiological studies in relation to both plant pathology and allergy. The later inventions of the Rotorod (Perkins, 1957) and the Rotoslide (Ogden & Raynor, 1967), although widely used in America, are not suitable for continuous operation. Kramer & Pady (1966) describe a spore

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sampler similar to our final design, but it has apparently not been compared with the Hirst spore trap. Air sampling methods have been extensively reviewed by Davies (1971), Gregory (1973) and Hyde (1972).

In Derby, pollen and spore counting began in 1965, using a home-constructed air sampling device as there were no funds to purchase a Hirst trap at that time. This model was developed into the present design by 1968, using similar principles to the Hirst automatic volumetric trap, but in a simplified form.

As the majority of recent studies of airborne pollen and spores reported in this country have used the Hirst trap, it was essential to compare the results by operating the air samplers side by side.

Materials and methods

Technical details of the Morrow Brown spore trap

Figs 1, 2 and 3 illustrate the basic features of the design for 24 hr sampling, in which the impactor unit lies in a horizontal plane. The coated slide (76×25 mm) is placed in a milled slot in the slide carrier, which is a machined metal block drawn along the brass bars at a rate of 2.0 mm/hr by means of a wire attached to a pulley on the clock. The whole assembly is enclosed in a metal casting with a lid, closed by thumb screws and made air-tight by a rubber seal. The orifice is set into the lid and measures 2.0×14 mm at the outer edge, tapering to 0.5×14 mm at the inner edge. The distance between the inner edge of the orifice and the impacting surface is 0.5 mm. Around the orifice is a circular wire gauze of 0.75 mm mesh surmounted by a rain shield, so that both insects and rain are excluded.

An accurate flow meter (G.A. Platon gap meter) is attached to the inlet pipe, and the air flow adjusted to 10 l/min. The whole unit stands on three adjustable legs, raising it approximately 1.0 m above the ground. Daily attention involves unscrewing the lid, removing the exposed slide and inserting a new one. The pulley on the clock is then released by a knurled knob, so that the carrier can be moved back until it is almost touching the stop at the end of the brass bars. Having tightened the pulley and ensured that the wire is taut, the lid is replaced and the screws tightened. The clock is wound once a week and the orifice cleaned.

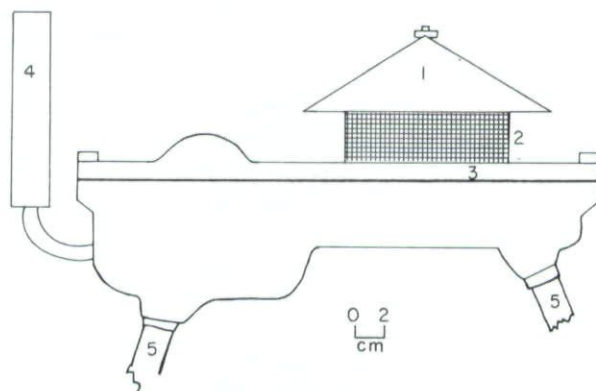


Fig. 1. Side view of the Morrow Brown spore trap. (1) Rain shield, (2) wire gauze, (3) lid, (4) flow meter, (5) legs (length 80 cm).

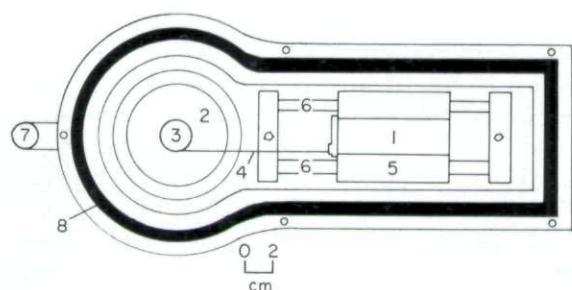


Fig. 2. Top view of the M.B. spore trap with lid removed. (1) Coated slide, (2) clock, (3) clock spindle, (4) nylon cord, (5) slide carrier, (6) slide carrier runners, (7) air exit pipe, (8) rubber seal.

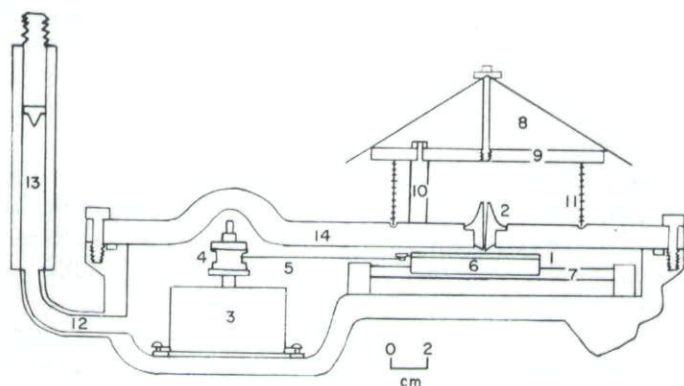


Fig. 3. M.B. spore trap, longitudinal section. (1) Coated slide, (2) orifice, tapering to 0.5 mm at inner edge, (3) clock, (4) clock spindle, 15 mm diameter, (5) nylon cord, (6) slide carrier, (7) slide carrier runners, (8) rain shield, (9) supporting plate for rain shield, (10) supporting pillar, (11) wire gauze cylinder, (12) air exit pipe, (13) flow meter, (14) lid.

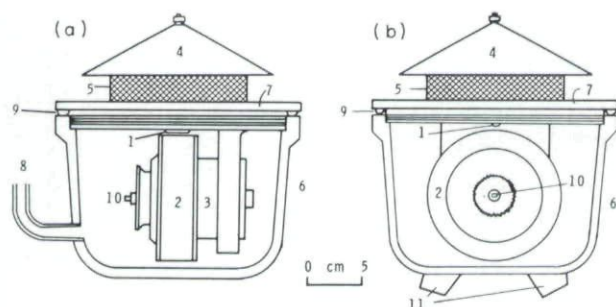


Fig. 4. 7 day drum type spore trap, cutaway drawings. (a) Side view; (b) front view. (1) Inner end of orifice, (2) adhesive-coated drum, (3) clock, (4) rain shield, (5) wire gauze, (6) metal casing, (7) lid, (8) air exit pipe (to flow meter), (9) rubber seal, (10) clock spindle, (11) attachments of legs.

Drum type 7 day spore trap

For use in the surveys to be reported subsequently it was necessary to have a version of the spore trap which would run unattended for 7 days. The model developed in Derby is similar to an alternative version of the Hirst trap made by the Burkard Manufacturing Co., in which spores are collected on a coated transparent plastic strip wrapped

round a drum which rotated once in 7 days. This version is illustrated in Fig. 4. Again the orifice is directed upwards and is surrounded by gauze and protected by a rain shield of exactly the same design as that of the slide trap. The distance from orifice to the petroleum jelly layer and other critical dimensions being identical, comparative trials were unnecessary.

Slide coating jigs

Morrow Brown trap. Petroleum jelly was found to be the most satisfactory material for coating the slides. The standard 0.5 mm gap between orifice and adhesive surface necessitated some means of making the coating absolutely flat, as the distance between the inner edge of the orifice and the impacting surface is critical. The jig shown in Fig. 5 was therefore devised so that the thickness of the slide plus the adhesive layer could be made standard, whatever the thickness of the slide itself. Petroleum jelly, with the addition of 5% paraffin wax in very hot weather, is poured into the channel, allowed to set, the excess shaved off with a sharp blade, and the surface flamed to produce a smooth finish. This is a considerable advantage when examining the slide, as the amount of refocussing required is minimal.

Hirst trap. For use in the Hirst spore trap a different slide coating jig had to be made, because the construction of the slide carrier is such that the distance from the orifice to the slide surface is constant (0.5 mm). Thus the problem is to standardize the thickness of the petroleum jelly layer, not the total thickness of slide plus adhesive.

This jig is illustrated in Fig. 5, the slide being inserted under two metal strips, the thickness of which governs the thickness of the adhesive layer, and the slide is held against the strips by a spring underneath. The surplus petroleum jelly is shaved off as

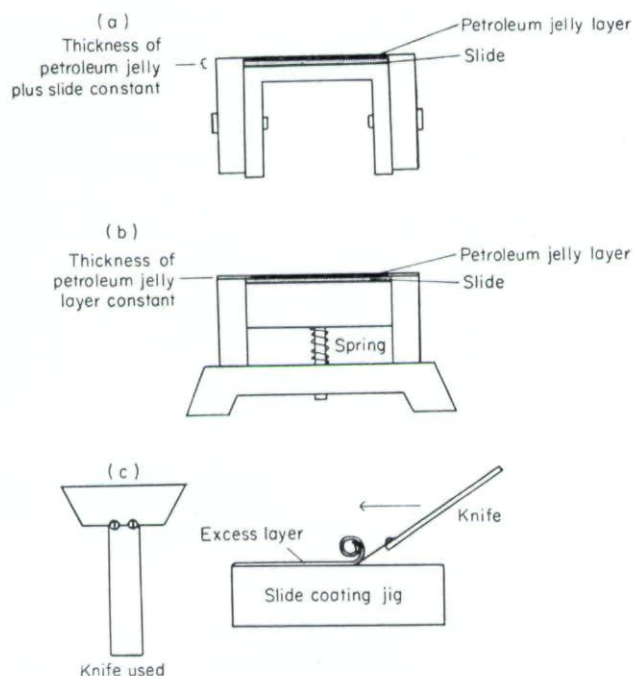


Fig. 5. (a) Slide coating jig for M.B. trap, end view; (b) slide coating jig for Hirst trap, end view; (c) method used for removal of excess petroleum jelly.

before and the slide is flamed to produce a smooth surface. In this manner the distance from the orifice to the impacting surface was also standardized for purposes of comparison. It was found impossible to produce slides of standard thickness and sufficient smoothness for the Hirst trap other than by using a jig.

Morrow Brown trap—7 day version

The recommended method of coating the drum of the Burkard trap is to apply a thin film of 10% Gelvatol to the plastic strip, followed by petroleum jelly plus 10% paraffin wax in toluene using a brush. However, we found that a really good surface could only be obtained by rotating the drum in the holder supplied by the manufacturers, dipping into a small trough of molten petroleum jelly, shaving off the excess by use of a sharp blade and finally flaming the surface to produce a smooth finish. The exposed strip is removed, cut into sections, mounted on slides and counted in the usual way.

Comparative trials

Comparative trials of efficiency were made with the Hirst and M.B. traps beside each other on a large lawn belonging to one of us (H.M.B.) which had not been cut for a year, the orifices being 1.0 m above ground level; and also on the roof of the Derby Chest Clinic, 10 m above ground level. It was decided that it was best to carry out the comparisons under field conditions.

Counting and mounting techniques

Daily mean concentrations of pollen and spores were obtained by counting along the full length of the slide. Polyvinyl lactophenol, containing cotton blue, was used as mountant. This stain has the disadvantage of obscuring the colour of many spores, but was considered essential because of the large amount of dirt and fly ash retained

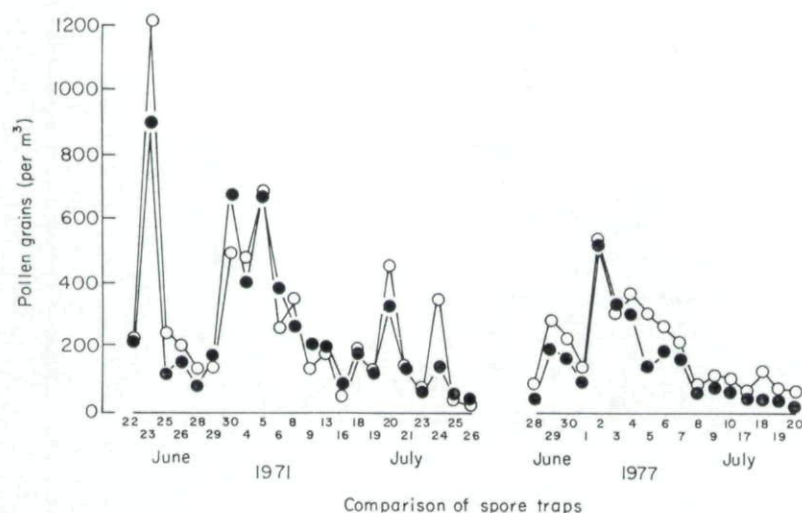


Fig. 6. Comparison of Hirst (●) and M.B. (○) spore traps in the field: daily average figures for grass pollen. Counts are missing for some days, for technical reasons. Results are only shown for days when slides from both traps were available.

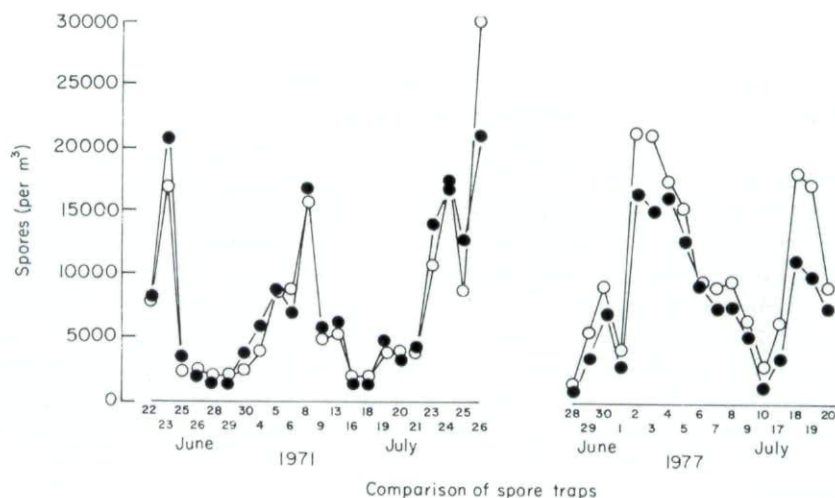


Fig. 7. Comparison of Hirst (●) and M.B. (○) spore traps in the field: daily average figures for *Cladosporium*. Counts are missing for some days, for technical reasons. Results are only shown for days when slides from both traps were available.

on all slides. 10 mm wide cover-slips were used and mountant applied with a tuberculin syringe to prevent movement of the pollen grains during mounting as far as possible; we had found that when using a full width cover-slip there was a tendency for pollen grains to float to the edges and drop down the side of the petroleum jelly layer, where they were not counted.

Results

The traps were run as described for a total of 40 days on the roof of the Derby Chest

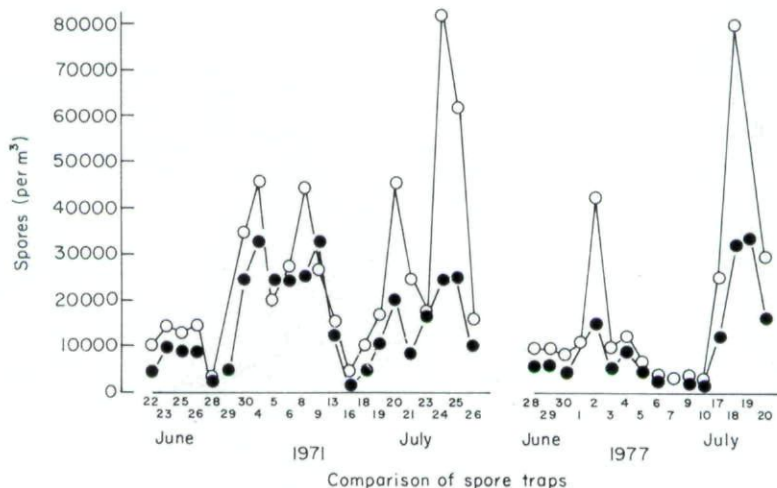


Fig. 8. Comparison of Hirst (●) and M.B. (○) spore taps in the field: daily average figures for *Sporobolomyces*. Counts are missing for some days, for technical reasons. Results are only shown for days when slides from both traps were available.

Table 1. Comparison of spore traps—overall results

Spore/pollen	M.B. trap figure expressed as percentage of Hirst trap	Averaging period (days)
<i>Alternaria</i>	102	25
<i>Cladosporium</i>	120	63
<i>Ustilago</i>	129	63
<i>Sporobolomyces</i>	166	38
<i>Tilletiopsis</i>	201	38
Grass pollen	136	38

Clinic and for 23 days on the author's lawn, and comparative results are shown graphically in Figs 6 to 8.

In Table 1, average figures obtained using the M.B. trap are expressed as a percentage of those obtained with the Hirst trap. The collection efficiency of the two traps is similar insofar as larger particles are concerned, but the Morrow Brown traps show the expected increase in efficiency in relation to small spores such as *Sporobolomyces*. The high figures for grass pollen obtained by the M.B. trap are unexpected and require further investigation. Some day to day variation in the proportion of the catch between the two types of trap occurred, due to inevitable sampling errors.

Discussion

The Hirst trap is designed to operate isokinetically, as discussed by May (1945, 1967). The orifice is kept facing the wind by a wind vane attached opposite the orifice. It is stated that the device operates approximately isokinetically at normally encountered wind speeds, but in practice in the open air the wind speed is constantly varying and the theoretically ideal isokinetic conditions can seldom be achieved. (Watson, 1954; Davies, 1971). Ideally a continuous record of wind speed while the trap was operating could be kept and a correction factor applied to the counts, or the wind speed could be made to alter the suction rate automatically.

Previous studies (Hirst, 1952) of the efficiency of the Hirst trap operating at 10 l/min, as compared with the cascade impactor (taking the latter as being 100% efficient) showed in wind tunnel experiments that the Hirst trap was 85–90% efficient in trapping *Lycopodium* spores at wind speeds of 1.5 m/sec and 9.0 m/sec, falling to around 70% at 5.0 to 6.0 m/sec. However, this was under controlled conditions at constant wind speeds, and it is particularly relevant that smaller particles of 5.0 μm or less are less affected by isokinetic conditions (May, 1967). The Hirst trap was originally designed to estimate the larger spored plant pathogenic fungi. Very small spores, such as *Sporobolomyces* (2.0–5.0 μm), may be underestimated and the Hirst trap, on the basis of impaction velocity, should catch only 50% of particles 4.0 μm in diameter (Davies, 1971).

The M.B. spore trap does not sample isokinetically, and has an orifice facing upwards and surrounded by wire gauze. The result is that a zone of relatively still air surrounds the orifice, which will tend to eliminate the effects of air speed and turbulence, resulting in conditions which resemble 'stagnation point' sampling (May, 1967).

Our spore trap was deliberately designed to retain a higher proportion of small

spores such as *Sporobolomyces*, which has been shown to be an important allergen in this area (Evans, 1965), and for this reason the 0.5 mm slit width was chosen. The velocity through the slit of the Hirst trap (14 mm $\times$ 2.0 mm) at a flow rate of 10 l/min is about 6.0 m/sec, whereas that through a slit 14 $\times$ 0.5 mm would be 24 m/sec. Applying a calculation and graphic data supplied by May (personal communication) the Hirst trap would be expected to capture 75% of particles 6.5 μ m in diameter and 100% of particles of 8.0 μ m and above. For the narrower slit and the same flow rate, the figures would be 75% for particles 1.6 μ m in diameter and 100% for 2.5 μ m and upwards, assuming 100% retention of particles. A similar result may be arrived at using particle terminal velocities. From these figures it is clear that for small spores the collection efficiency of the M.B. trap should be considerably higher.

It is evident from the data presented that the performance of the M.B. spore trap is comparable to that of the Hirst trap for larger particles (down to 10 μ m diameter) and considerably better for small particles (down to 1.0–2.0 μ m). As already stated, *Sporobolomyces*, with spores 1.0–5.0 μ m diameter, is an important constituent of the airspora on account of its allergenicity.

The M.B. design presents several advantages over the Hirst trap. One major benefit is that slide changing is much easier, important when trying to do this on a roof in wind and rain. During operation of the M.B. trap, rain is completely excluded, whereas rain occasionally enters the orifice of the Hirst trap. More accurate timing of any spore deposit is possible because the 0.5 mm orifice width allows the timing to be determined to within 0.5 hr, the corresponding figure for the Hirst trap with the 2.0 mm orifice being 2 hr. It was considered that the flow meter fitted to the Hirst trap was not sufficiently accurate and therefore we fitted the same type to both traps.

The M.B. spore trap is robust, compact and portable and would be cheaper to produce, although it is not available commercially at the moment. Its main disadvantage is perhaps the trapping of larger amounts of dirt, especially the fine particles.

Acknowledgments

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