AIRBORNE BACTERIA IN COTTON MILLS

I: SURVEY OF COUNTS OF VIABLE BACTERIA

BY

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The pulmonary disorder known as byssinosis (Prausnitz, 1936; Caminita, Baum, Neal, and Schneiter, 1947) which affects the operatives in the card-rooms of cotton spinning mills is usually attributed to the high concentrations of dust in the card-room air. The concentration of airborne bacteria has, however, been found to be abnormally high in these rooms; and also the counts of viable bacteria and fungi in cotton waste extracted by machines and air-cleaning plant in mills spinning raw cotton (see also Furness and Maitland, 1952). Although byssinosis may take 20 years to develop and cannot be due to bacterial infection in the ordinary sense, the possibility of dead and viable microorganisms in cotton dust playing some part in its aetiology cannot be excluded.

The survey of counts was initially carried out in card-rooms in full production in eight spinning mills chosen to cover a variety of types: two mills spinning mainly Egyptian cotton, two mills spinning mainly American cotton, two mills spinning mainly Indian cotton, one cotton waste spinning mill, one rayon spinning mill. The results are given in Table 1, in which relevant data from later work have also been included. Results for other sites in the mills were also obtained, but those for spinning rooms and later stages of processing, including weaving, as well as those referring to rayon have been omitted from the table; they are sufficiently indicated in the outline of conclusions given below. Outside control counts were not usually made, but the cotton card-room counts are so high that such controls would in most cases have little significance.

A Bourdillon type slit sampler (Bourdillon, Lidwell, and Thomas, 1941) was used, and in the early work the plates were, generally speaking, very overcrowded so that systematic errors affected the counts per cubic foot. Corrections have been made, but random errors remain and are probably large, since the numbers of plates taken at any one site in our early work were small. This however

does not invalidate the following broad conclusions.

In a normal card-room processing raw cotton on rotating flat cards the bacterial count among the cards in production is exceptionally high, running usually to several thousands per cubic foot.

In the same card-room, but among the speed frames and away from the cards, a much lower count of the order of 500 to 1,000 per cu. ft. is found. A similar reduction was found when the sampler was moved from cards processing cotton to others processing rayon staple fibre in the same room (Table 1, Mill No. 5). Even these lower counts are high by ordinary standards.

In the pre-carding processes on raw cotton (cotton mixing, blow-room) the counts are comparable with those between cotton cards in production in spite of the more enclosed nature of the machinery, but local variations of concentration are probably more marked than in the card-room.

In the spinning rooms the counts are mostly of the order of 50 to 200 per cu. ft., which are numerically comparable with those found in such rooms as a canteen or a crowded office, though as Hamlin shows below, the types of organisms present are still those characteristic of the card-room rather than of a room with a relatively high human population.

Plates taken in canteens and offices inside the mills show colonies which are obviously of different types from those found on plates from the cotton workrooms.

In a weaving shed the counts are of the same order as those in the spinning rooms.

In a mill working on viscose rayon staple fibre (with a little acetate rayon) the counts, even where the material was going through the rotating flat cards, were less than 10 per cu. ft., which is indistinguishable from an outside control count.

In the card-rooms of the cotton waste mills visited the maximum bacterial count was 230 per cu. ft. as compared with the thousands in an ordinary cotton card-room, and two factors may be respon-

TABLE 1
BACTERIAL COUNTS* IN COTTON MILLS

Mill	Type of Material	Bale Opening Room	Cotton Mixing Chamber	Devil-room	Blow-room	Card-room (Cards)	Card-room (Speed Frames)	Speed Frames (Separate Room)
No. 1	<i>Raw Cotton</i> 65% American (plus other cottons)	—	—	—	—	3,500	—	4,600‡
No. 1 (repeat visit)	58% American, 23% Egyptian (plus others)	—	—	—	1,200	1,800	—	580
No. 2	65% American (plus other cottons)	—	—	—	—	8,100	—	—
No. 3	25% American (plus other cottons)	—	—	—	—	6,500	—	—
No. 3 (same visit)	8 parts Indian plus 1 part Congo cotton	—	—	—	3,300	3,200	1,500	—
No. 4	100% Indian (Oomras)	—	—	—	12,000 } 2,600 }	2,700	—	—
No. 5	100% Egyptian	79	—	—	—	7,200†	290	—
No. 6	100% Egyptian	—	1,300	—	950	930	59	48
No. 9 (two visits)	100% Egyptian	—	—	—	—	2,700 } 3,400 }	—	—
Nos. 10–15 (mean of many visits)	American plus Brazilian	—	—	—	—	11,700	—	—
No. 16	100% Sudanese	—	—	—	—	4,800	—	—
No. 7	<i>Cotton Waste</i> Mixed hard and soft	—	—	400	180 (scutcher)	41 (breaker cards) 31 (finisher cards)	—	—
No. 17	Mixed hard and soft waste	—	—	1,700	—	230 (breaker cards)	—	—

* Counts per cubic foot of air of organisms growing aerobically at 37°C on nutrient agar.

† Near cards on viscose rayon in the same room the count was 420.

‡ An abnormally high count, never again approached in such a room. The repeat visit gave a typical figure.

sible for this striking difference. In the first place the "hard waste" cotton has already been processed once and much of the trash and dust removed, and secondly these mills use roller-clearer cards instead of flat cards. (Roller-clearer cards are hooded and fitted with exhaust ducting so that much of the ejected material is carried off immediately and does not enter the general air of the card-room.) On the evidence available it is not possible to distinguish between the effects of these two factors, but the indications suggest that the exhaust system has the greater effect.

The counts at the pre-carding processes in a waste mill (devil-room, scutcher) are well above those in the card-room of the same mill and are high by normal standards, though still below those in ordinary cotton blow-rooms or card-rooms.

Discussion

It is legitimate to deduce from these results, taken in conjunction with those of the subsequent paper on the type distribution of the organisms, that the

very high counts of bacteria in cotton card-rooms are associated with the dirt and trash which are imported with the cotton in the bale, and that the organisms originate in the soil of the cotton fields. Once the material has left the card-room the counts drop to a low level, though whether this is because the trash has been removed or because the cotton is in a less open condition is not certain; the higher count on reopening the spun cotton in the devil-room suggests that the latter factor is at least partly responsible. Cellulose which has been chemically dissolved and regenerated in the form of rayon fibres is virtually sterile.

Although the bacteria are associated with the dirt in the cotton as received, the ratio of the number of organisms to the number and mass of dust particles may vary widely with cottons of different origin or of different crop years. There seems, for instance, to be a definite tendency for American cottons to give a higher bacterial count and often a lower dust count than either Egyptian or Indian types (see Table 1, Mill No. 3, for a

comparison of counts between cards on American types and cards on Indian types in the same card-room), and we have recently obtained evidence of a marked increase in the bacterial content of certain American and Brazilian cottons in the 1950 season as compared with 1949.

Summary

Counts of airborne bacteria have been made at various sites in cotton mills. They are exceptionally high in the card-rooms and at pre-carding processes but much less at the spinning and later processes. They are comparatively small in a waste mill card-room but rather higher in the devil-room.

At all sites in a rayon mill the counts were indistinguishable from control counts.

In cotton mills the general level of counts depends on the source of the cotton and tends to be highest with American types; even for any one type it probably also depends on the crop year.

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II. DETERMINATION OF TYPES OF VIABLE BACTERIA

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An examination of the types of bacteria present in the air has been made in cotton mills using cottons of various origins. The organisms were collected on solid media in a Bourdillon type slit sampler and exposures were adjusted so that no plate from which subcultures were made carried more than 200 colonies. In all cases the medium was made up with 5% agar since at lower concentrations some colonies tended to spread.

Samples were taken in two cotton spinning mills. The first of these was visited twice and samples were collected in the card-room and at various other sites. Blood and nutrient agar were used in each case, and on the second occasion anaerobic as well as aerobic incubation was employed. One visit only was paid to the second mill and samples were only taken in the card-room; blood and nutrient agar plates were exposed, some being incubated aerobically and others anaerobically.

In order to find whether the distribution of genera changed substantially as the cotton reached later stages of processing, visits were also made to a waste spinning mill and to two weaving sheds. The results from the spinning mills had shown that there was no significant difference between the types found on blood agar and those on nutrient agar and also that no obligate anaerobes were detected; therefore on these later visits only aerobic cultures on nutrient agar were examined.

Details are given in Table 1.

After incubation colonies were subcultured from the aerobic plates to slopes, and from anaerobic

plates to stabs; those from blood agar plates to blood and nutrient agar, those from nutrient agar plates to this medium only. It was found that all the organisms would grow well on nutrient agar slopes, and the cultures were therefore maintained in this way. The organisms were assigned to their genera according to Bergey's classification (Bergey, 1948). The results are given in Table 2. The numbers of colonies examined and on which the counts per cubic foot were based are shown in brackets. High absolute accuracy is not claimed and the figures are intended for comparison within the table. For the less abundant types of organisms the number of colonies was very small and here in particular the accuracy is low.

Discussion

The investigation showed that the bulk of the organisms in the card-room air belonged to those genera which are commonly associated with soil and water, especially the former. No true anaerobes were isolated, and organisms commonly found in the respiratory tract were virtually absent.

The genus *Bacillus* always predominated in the aerobic cultures, but the genus next in order of abundance has varied. The data are not sufficiently extensive to show whether the variation arose from differences in mill conditions or from the different mixings of cotton.

The total count based on anaerobic cultures was one-fifth or less of that obtained with aerobic cultures. *Bacillus* was very much suppressed but