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Characterization of the aerosol in turkey rearing confinements

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A study was conducted to characterize the aerosol found in turkey rearing confinements, to study biological response to inhalation of the aerosol, and to evaluate a water spray, dust suppression system in one confinement as compared to a control barn. A significant reduction in aerosol concentration in the *"sprayed"* barn was inferred by many environmental and biological sampling parameters. Similarity of physical and biological factors in both study populations, with the exception of the dust suppression system, implied that a mortality rate increase of 1.74 of control versus *"sprayed"* barn was directly related to aerosol concentration.

Characterization of the aerosol in turkey rearing confinements

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introduction

The exposure of agricultural workers to aerosols in their work environment has resulted in clinical characterization of a variety of hypersensitivity lung diseases.[1-9] The clinical manifestations of the hypersensitivity lung diseases; farmers' lung, grain fever, and extrinsic allergic alveolitis or more commonly pigeon breeders' disease are similar, and are characterized by Type I and/or Type III immunologic response. In the case of farmers' lung, the etiologic agent is widely accepted as the thermophilic actinomycete *Ther mopolyspore polyspora,* while the elucidation of the causative agent in pigeon breeders' disease is only in the speculative phase.[8] The majority of authors reviewed, however, feel that pigeon breeders' disease results from exposure to some protein fraction of bird (pigeons, parakeets, turkeys, chickens) fecal matter which becomes aerosolized.[3,7-9]

A hypersensitivity lung disease characteristic of pigeon breeders' disease has been associated with exposure of workers to the aerosol generated during the handling and confinement raising of turkeys.[2] At present there is a paucity of published studies in which environmental monitoring and biological monitoring has been performed in turkey rearing confinements. The need to characterize the aerosol found in turkey confinements is basic to the elucidation of the etiologic agent of the hypersensitivity lung disease seen in workers exposed to these aerosols. Through the collection of both environmental and biological samples, under natural production conditions, it was felt that baseline information on the aerosol and its effect would be gained. Consequently, this study was designed to characterize the aerosol found in turkey rearing confinements, to study biological response to inhalation by the turkeys of the aerosol, and to evaluate a water spray, dust suppression system.

methods and materials

To accomplish the study objectives, two turkey rearing confinements, one with a water spray dust suppression system (sprayed barn) and one without (control barn), were selected for study. The two confinement barns were constructed of the same materials, were of the same dimension, were physically separated by approximately forty yards, and at the onset of the study both housed approximately 5,700 turkeys originating from the same hatchery.

environmental sampling and analysis

To evaluate the type and amount of aerosol present in turkey rearing confinements, five types of paired area dust samples were collected weekly over a seventeen week period. The sample period was selected to coincide with the hottest and, therefore, dustiest time of year (June-October, 1979). The dust samples collected were:

a) total dust before dawn in the bird breathing zone;
b) total dust after dawn in the bird breathing zone;
c) total dust after dawn in the human breathing zone;
d) respirable dust after dawn in the bird breathing zone;
e) particulate sizing and counting samples after dawn in the bird breathing zone.

The post dawn samples were collected following 20 minutes of sprinkling in the sprayed barn.

All dust samples were collected on Gelman DM-800 membrane filters, mounted in three piece 37 mm cassettes; with the exception of the respirable mass sample, the open face cassette technique was utilized. The total dust samples in the bird breathing zone were taken with a Bendix sequential sampler, regulated via 1 Lpm critical orifices. All other dust samples were collected with regularly calibrated M.S.A. model G personal sampling pumps. All of the dust samples other than the samples for particulate sizing and counting were taken over a one hour sampling period. The sampling period for the particulate sizing and counting samples was variable, depending on the concentrations of the aerosol. The flow rate used for the particulate sizing and counting samples was 2 Lpm. The same flow rate (2 Lpm) was used for the total dust human breathing zone sample, while a flow rate of 1.7 Lpm was used for the respirable mass sample. The flow rate of M.S.A. pumps was maintained by a minimum of

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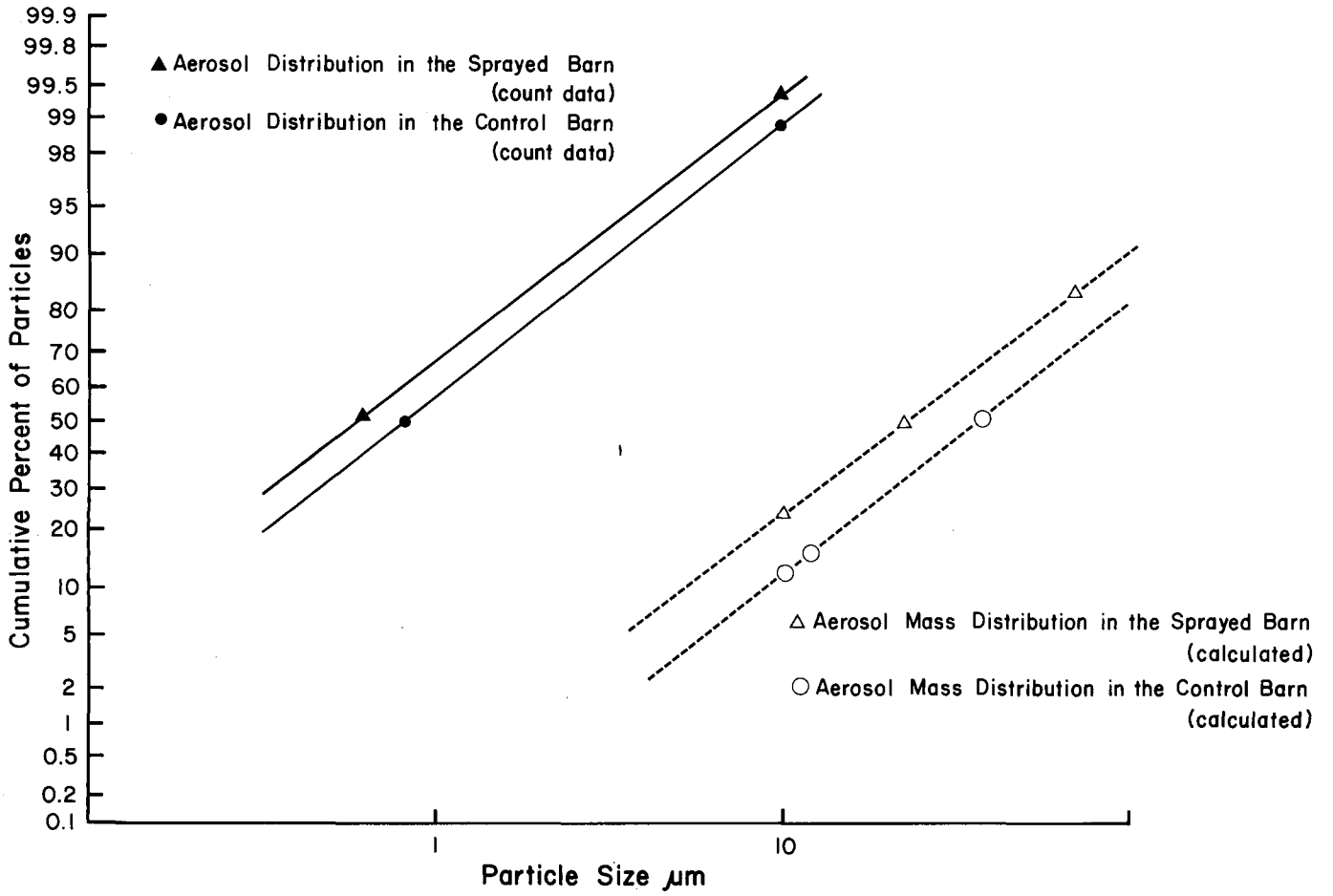


Figure 1 — Aerosol Distribution Plots and Calculated Mass Distribution plots for the Sprayed and Control Barns (plotted on logarithmic-probability paper).

four visual checks of rotometers per sampling period with flow adjustments as necessary.

Gravimetric determination (mg/ M^3) of concentration was utilized for the total dust and mass respirable samples. The analytical technique for particulate sizing and counting required preparation similar to the NIOSH method utilized for evaluation of personal asbestos samples.[10] With the sample mounted, microscopic analysis using a polarized light technique was performed. The polarized light technique was employed for the increased contrast provided with the complex aerosol encountered. Microscopic sizing and counting of particles was accomplished by use of a Porton reticle, as described by Silverman.[11] A cumulative percent of particles in each size interval was plotted versus geometric diameters on logarithmic-probability graph paper (Figure 1). After drawing the line of best fit through the points, the geometric particle diameter (Mp), the geometric standard deviation (σp), and the respirable fraction ($\leqslant 10$ μm) were determined from the graph. An aerosol concentration in millions of particles per cubic meter (mppcm) was determined from particle count data.

biological sampling and analysis

Biological samples were collected bi-weekly and consisted of blood samples and live birds. Additionally, weekly total mortality data were collected. Mortality data for each barn were subjected to statistical analysis for use as an indicator of were subjected to statistical analysis for use as an indicator of relative bird health and as an evaluation of the dust suppression system. The live birds and blood samples were transported to a laboratory in Longmont, CO for analysis.

Twenty blood samples were collected at random from each barn and the blood was allowed to separate into formed units and serum. The serum was subsequently surveyed for precipitating antibodies against three bacterial organisms; *(Mycoplasma gallisepticum, M. synoviae, M. meleagridis),* and one viral organism (Newcastle virus). The bacterial organisms were initially surveyed by the plate test, and those that gave positive tests were confirmed by hemagglutination-inhibition testing. The Newscastle virus was surveyed by hemagglutination-inhibition testing (microtiter technique).

The live birds were selected on a subjective determination of one *"health"* and two *"sick"* birds from each barn. At the laboratory, the birds were subjected to gross pathologic antemortem and postmortem examination. A primary concern in these examinations was the condition of the respiratory system. In addition to the gross pathologic examination, tissue samples from the nasal turbinates, tracheas, and lungs were collected and transferred to the Pathology Department at Colorado State University. The pathology laboratory, under the direction of Dr. Charles Whiteman, prepared and examined the tissues submitted.

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TABLE I
Summary of t-test Analysis

Parameter	Sample Size	Mean Concentration Control	Mean Concentration Sprayed	Standard Deviation Control	Standard Deviation Sprayed	2-Tailed Probability
Total Dust, BD[A], BBZ[B] (mg/M^3)	15	6.5	5.3	7.8	6.7	0.084
Total Dust, AD[C], BBZ (mg/M^3)	14	16.2	5.1	10.0	4.7	<0.0005
Total Dust, AD, HBZ[D] (mg/M^3)	12	12.4	4.2	5.3	2.6	<0.0005
Respirable Mass, AD, BBZ (mg/M^3)	14	2.6	0.8	2.0	1.3	0.002
Particle Count, AD, BBZ (mppcM)	12	457.6	126.0	305.4	68.3	0.003
Avg. Median Particle Diameter (μm)	12	0.8	0.6	0.2	0.1	0.014
Avg. Geometric Standard Deviation	12	3.1	3.0	0.6	0.6	0.657
Avg. Percent Respirable (<10 μm Diameter)	12	98.8	99.4	1.0	0.5	0.120
Relative Humidity	14	72.1	70.6	2.4	2.4	0.002
Temperature (°C)	17	30.2	30.0	3.3	3.3	0.416

[A]Collected before dawn
[B]Bird breathing zone sample
[C]Collected after dawn, following sprinkling
[D]Human breathing zone sample

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data analysis

Following completion of the data tabulation, statistical analyses were performed to determine if significant differences existed between the sprayed and control barns for the various study parameters. The paired dust samples were subjected to the students paired t-test and Pierson correlation statistic. The mortality data was subjected to chi-square and the Pierson correlation statistical analyses. The incidence of airsacculitis in the sprayed and control barns was tested by 2 x 2 Fisher exact analysis. The serology and gross and histologic pathology findings were not amenable to rigorous statistical analyses. The intent of the statistical analyses was to determine if significant differences in the concentration and/or characteristics of the aerosol or the biological response of the birds existed in the sprayed versus control barns.

results and discussion

Environmental samples were collected during pre and post dawn sampling periods. The only sample type collected during the pre dawn sampling period was the total dust in the bird breathing zone. This sample functioned as an internal control for this study. The control was to determine if significant differences in dust concentration existed in the two turkey confinements that were not a result of use of the dust control system. When comparison of this sample type in the sprayed and control barn was made, no significant differences at the 0.05 level was detected ($p = 0.084$). This suggests that the two barns were experiencing comparable environmental conditions. During the post dawn sampling period, a number of sample types were collected *(see materials and methods)*. When comparison of aerosol sample types in the sprayed barn were made with their respective matched sample in the control barn, a significant difference was noted in all cases (Table I). As reflected by the mean concentrations, the aerosol concentration was consistently and substantially lower in the sprayed barn as compared to the control barn. Since it was determined that no significant differences existed between the two barns prior to use of the water spray-dust suppression system, it was concluded that the reduction in aerosol concentration resulted from use of the dust suppression system.

Microscopic sizing and counting indicated that the aerosol in the sprayed and control barn had virtually identical distribution. Figure 1 is a logarithmic-probability plot of the aerosol in the sprayed and control barns, along with the respective mass median diameter plots. As indicated in Table I, the average geometric standard deviations for the

TABLE II
Chi Square Analysis of Total Mortality in the Subject and Control Barns

	Sprayed Barn	Control Barn	Totals
Dead			
Observed	221	384	
Expected	302.5	302.5	605
Alive			
Observed	5479	5316	
Expected	5397.5	5397.5	10,795
Totals	5700	5700	11,400

$\chi^2 0.05,1 = 3.84$
χ^2 (cal.) = 45.81 ($p < 0.001$)

TABLE III
Comparison of the Incidence of Airsacculitis in the Anterior, Posterior, and Thoracic Airsacs Between the Subject and Control Barns

Airsac	Sprayed Barn Yes	Sprayed Barn No	Control Barn Yes	Control Barn No	p-Value*
Anterior	10	8	6	12	0.1573
Posterior	8	10	8	10	0.6310
Thoracic	10	8	6	12	0.3666

*2 x 2 exact analysis

aerosol distributions were essentially the same. The shift in median particle diameter resulted from proportionated removal of particles by the dust suppression system. From Figure 1 it was shown that 99.4 percent of the total particles counted were 10 μm or less in diameter in the sprayed barn compared to 98.8 percent in the control barn. When the mass median diameter plot was made, it was shown that 24 percent of the aerosol by mass was 10 μm or less in the control barn compared to 12 percent in the sprayed barn. These percent respirable (mass) count values are in theory comparable to percent respirable by mass values as determined by gravimetric procedures. This gravimetric estimation of the percent respirable by mass is determined by dividing the *respirable mass* concentration by the *total dust* concentration. When the calculations were performed, it was shown that the aerosol based on respirable mass sampling was 16.0 percent in the sprayed barn and 15.0 percent in the control barn. While the values for the sprayed and control barn are not the same by the two methods, the discrepancy is explainable. First, it must be noted that calculations of the mass median diameter assume a uniform density of the aerosol. Second, there is considerable error inherent in the two sampling methods.

The aerosol is complex in composition including mold spores, bacteria, dander, feather fragments, wood shavings and crystalline silica. Since inhalation of this aerosol might result in health effects to organ systems other than the nonciliated portions of the lung, it was felt that mass respirable sampling was not appropriate for human breathing zone samples but that only total dust sampling should be used.

Chi-square analysis indicated a significant difference in mortality, with the overall mortality in the control barn being 1.74 times that in the sprayed barn. (Table II). The difference in mortality was attributed to the lower aerosol concentration in the sprayed barn. This is plausible because it was unlikely that a difference in general health of the birds in the two barns existed, and it has been shown that the only environmental influence of significance was the reduced aerosol concentration in the sprayed barn. Analysis of the biological samples indicated no significant difference in the incidence of airsacculitis between birds from both barns (Table III). Serology indicated that birds from both barns gave positive tests for *Mycoplasma meleagridis* at the start of the study, and that birds from both gave positive tests for Newcastle disease by the tenth week of the study. These data support the comparability of the general health status of the birds in the two barns.

conclusion

The data indicated that the water spray dust suppression system effectively reduced the aerosol concentration in the sprayed barn. Further, the significant reduction in total mortality in the sprayed barn most likely resulted from the reduction in aerosol concentration. Finally, the information gained from this study provided the basis for future in-depth studies of complex organic aerosol exposures to animals and workers.

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