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DUST PRODUCTION of POULTRY LITTER MATERIALS

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DUST PRODUCTION of POULTRY LITTER MATERIALS

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ATMOSPHERIC DUST in poultry houses must be kept to a minimum for optimal poultry production. This is essential not only for the well being of birds and attendants, but also for the efficient operation of mechanical equipment. Studies were begun in 1960 to determine the origin of dust in poultry houses, its composition, and the quantity produced.

SOURCE OF DUST

Two types of particles were identified when samples of poultry dust were examined under the microscope. One type was long and cylindrical with nodes and internodes similar to sugar cane. These particles averaged some 4 microns wide and 110 microns long (1 micron equals 40 millionths inch) and were identified as broken feather debris. The second type of dust particle was flat and flaky, ranging in size from 1 to 450 microns. Because of their structure and chemical composition, these two types of particles form aggregates. These aggregates block filters, adhere to equipment surfaces, and create many problems in poultry management.

A series of tests using birds on wire and litter, with and without feed, and with feed in mash, crumble, or pellet form, was conducted to determine how much dust came from feed, litter, and

* Resigned.

the birds. Dust production from caged birds was much lower than from birds on litter, Figure 1. The dust from chambers where birds were fed mash was greater than for those fed crumbles or pellets. Feed dust for the three treatments represented some 20, 15, and 10 per cent, respectively, of the airborne dust. For birds on litter, the dust from feed represented a smaller percentage since most of the dust came from the litter. In floor studies where birds were placed on pine shaving litter, the litter dust was 50 to 60 per cent and that from the birds about 30 to 40 per cent.

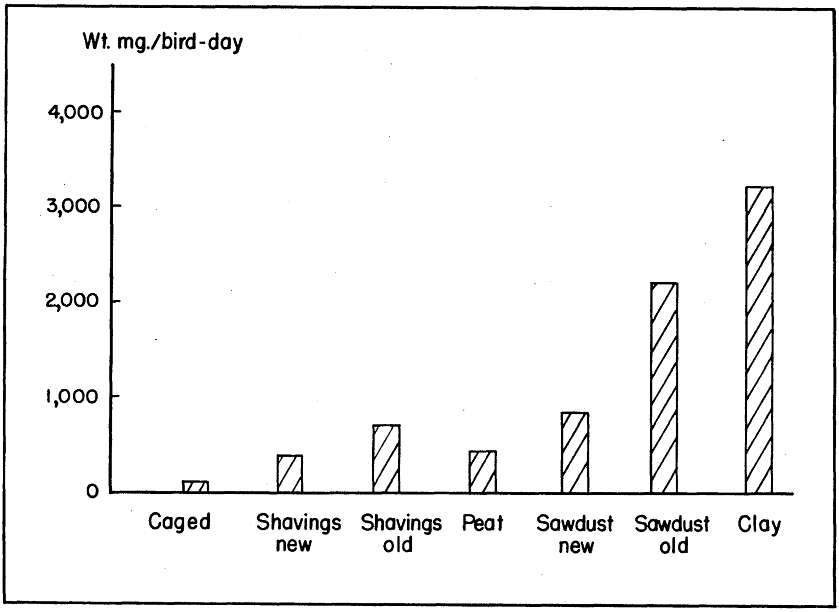

FIG. 1. Airborne dust production from caged laying hens and hens on various litter materials.

CHEMICAL COMPOSITION OF POULTRY HOUSE DUST

To determine the composition of dust in poultry houses, a series of chemical analyses was conducted on dust samples gathered in environmental chambers. These studies were carried out by Koon (2). The chambers used in these studies have been described by Grub, Rollo, and Howes (1), and the samples were gathered incidental to other studies. Dust samples were obtained from caged SCWL (H3w strain) hens maintained at different constant temperature regimes, Table 1. Similar dust samples were obtained for Pilch strain White Rock broiler chicks of different ages, Tables

2, 3, and 4. These birds were maintained on fresh shavings litter.

Each chamber measured 8 by 10 ft. with a 7-ft. ceiling and had a smooth white enamel interior surface that was covered with a polyethylene sheet. Each chamber had a capacity of either 44 individually caged laying hens or 80 broilers in batteries or on the floor.

TABLE 1. CHEMICAL ANALYSIS OF DUST PRODUCED BY SCWL HENS AT DIFFERENT ENVIRONMENTAL TEMPERATURES, AUBURN, ALABAMA

Temp.	Dry matter	Dry matter composition				
		Protein	Fat	Cellulose	CHO	Ash
°F	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
50	91.27	60.73	9.03	3.87	14.80	11.57
60	91.52	56.97	8.99	4.69	18.79	10.56
70	91.46	56.77	8.97	4.24	18.55	11.47
80	91.52	56.96	8.82	5.88	16.95	11.39
90	91.72	60.94	8.91	4.03	15.66	10.46
100	91.50	65.10	8.52	4.99	10.03	11.36

TABLE 2. EFFECT OF ENVIRONMENTAL TEMPERATURE AND AGE ON DRY MATTER OF DUST PRODUCED BY WHITE ROCK BROILERS, AUBURN, ALABAMA

Age	Dry matter of dust				
	55°F	65°F	75°F	85°F	95°F
Wks.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
2	96.04	96.33	95.91	95.36	96.21
3	96.37	95.11	95.07	94.37	94.99
4	96.79	96.45	94.91	95.91	95.84
5	96.67	96.14	96.36	96.38	94.74
6	97.15	96.45	96.33	96.03	95.99
7	96.23	97.34	96.35	97.26	95.21

TABLE 3. EFFECT OF ENVIRONMENTAL TEMPERATURE AND AGE ON CRUDE PROTEIN IN DUST PRODUCED BY WHITE ROCK BROILERS, AUBURN, ALABAMA

Age	Crude protein				
	55°F	65°F	75°F	85°F	95°F
Wks.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
2	80.33	91.92	89.19	73.91	67.82
3	85.29	79.89	89.93	92.52	83.71
4	85.37	91.24	87.43	87.94	90.58
5	89.73	90.50	94.05	85.04	84.10
6	88.04	86.81	92.64	86.34	84.91
7	86.65	88.17	88.76	92.41	78.61

The environment in each chamber was controlled with an individual system without air exchange among chambers. The temperature was held constant with a variation from the mean of ± 2°F. The relative humidity was maintained at 60 per cent with a variation of ± 5 per cent. Ventilation air was provided at the rate of 1 c.f.m. per bird, or approximately 4.7 air changes per

TABLE 4. EFFECT OF ENVIRONMENTAL TEMPERATURE AND AGE ON FAT IN DUST PRODUCED BY WHITE ROCK BROILERS, AUBURN, ALABAMA

Age	Fat				
	55°F	65°F	75°F	85°F	95°F
Wks.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
2	4.29	2.94	1.22	4.87	2.33
3	4.26	2.67	4.09	2.91	5.53
4	1.83	3.32	5.04	4.74	3.85
5	4.25	2.56	6.05	4.37	4.01
6	3.44	4.02	5.97	5.12	6.66
7	3.71	4.23	5.30	5.74	4.29

hour. All chambers were sealed to exclude light. Illumination was provided 14 hours per day by one 40-watt incandescent bulb located in the center of the ceiling.

Air was constantly recirculated through the chamber heat exchanger at an average rate of 270 c.f.m. or 29 recirculations each hour. The average air velocity in the chambers was 40 f.p.m.

The airborne dust collected in these studies was gathered on American Air Filter Company two-ply type 'S' filter paper held in a metal frame. The filter was mounted in the exhaust air duct and changed every 2 hours. Qualitative dust samples were obtained by shaking the dust from the filter paper onto a clean paper. Quantitative samples were obtained by oven drying the filter paper at 105°F for 24 hours before and after use. The equipment and chambers were thoroughly cleaned before the test. During the experimental period, measurements of dust adhering to chamber walls and equipment were made.

An examination of the data indicated that the dry matter content of the hen dust was approximately 91 per cent, Table 1. Expressed as a percentage of the dry matter, the protein, fat, cellulose, carbohydrate, and ash were respectively 60, 9, 5, 15, and 11 per cent. Similar data for the broiler chicks indicated that chick dust contained less moisture (96 per cent dry matter). The protein of the dry matter of the chick dust was much higher (90 per cent), whereas the fat was reduced (5 per cent). The latter dust was mostly accumulated from the loss of down feathers which appeared to give rise to a dust higher in dry matter and protein but containing less fat.

LITTER MATERIALS AND DUST PRODUCTION

Since most dust originated from litter in floor-housed systems, dust samples from laying hens on floor litter were collected in two chambers that were especially designed for the study of poultry dust. Each chamber measured 8 by 10 ft. with an 8 ft. ceiling. The interior chamber surfaces were constructed of smooth, galvanized sheet metal finished with a glossy white enamel. Cavity walls served as plenum chambers to eliminate heat transfer through the interior wall, floor, and ceiling surfaces. Individual chamber temperature and air moisture control were accomplished by preconditioning the incoming ventilation air. The replaced chamber air was exhausted to the exterior.

This design, a major modification of the twelve original Auburn psychrometric chambers, permitted temperature and air-moisture control without recirculation of chamber air through a heat exchanger. Air temperature was held constant at 80°F with a differential of ± 2°F. Relative humidity was held constant as indicated with a differential of ± 5 per cent. Both chambers were sealed to exclude solar light. Illumination was provided 14 hours per day by one 40-watt incandescent bulb located in the center of the ceiling. Ventilation air was provided at the rate of 50 c.f.m., or approximately 4.7 air changes per hour.

SCWL pullets with a density of 2 sq. ft. per bird were used in all studies. Continuous records of atmospheric and settled dust were obtained for pine shavings, sawdust, peat moss, clay, chopped corn cobs, rice hulls, and composted poultry litter.

The results of this 4-year study are presented in Figures 1, 2, and 3. These data showed that dust increased with the age of the material (pine shavings and sawdust). It is also obvious that the litter material greatly influenced dust production. Fresh pine shavings litter gave highly desirable results, whereas clay and composted litter (Litterlife) produced the greatest quantity of dust.

The results presented in Figures 1 and 3 were in terms of mg./bird/day, obtained as previously described. A more realistic comparison of dust production was made by comparing the drop in air velocity as it passed through filter paper which effectively collected dust particles as small as 1 micron in size, Figures 2 and 3. The change in velocity was reduced to bird-hour values, thereby eliminating variation because of population and time.

In some of the later studies, estimates of airborne dust have been successfully determined by using a Mine Safety "Fixt-Flo" sampler. This instrument is portable and draws air at a constant velocity through a dried pad of known weight. After a given period the pad is removed, dried, and reweighed.

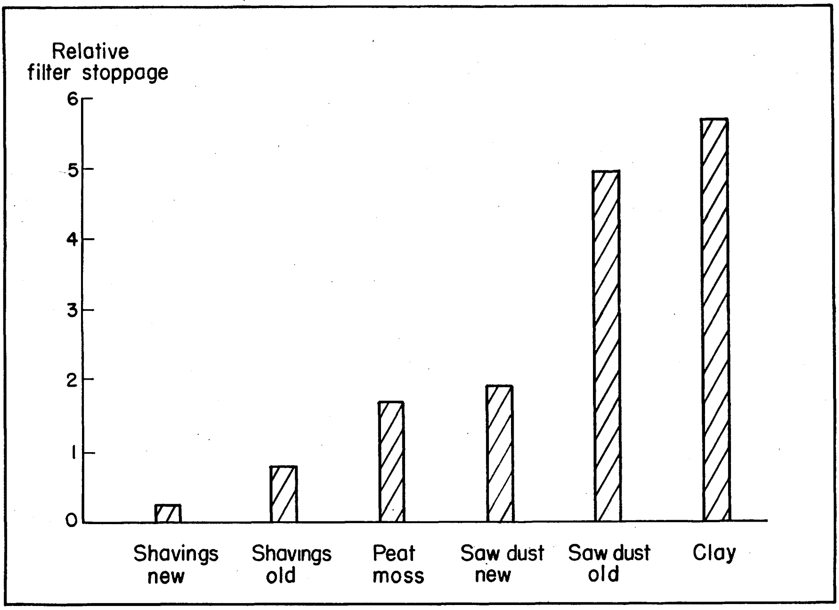

FIG. 2. Airborne dust production from laying hens on various litter materials as measured by relative filter stoppage.

DUST PRODUCTION AND ENVIRONMENTAL TEMPERATURE

In studies with H3w strain SCWL hens previously described in the section dealing with the chemical composition of dust, data for dust production were also collected. These data showed that dust production from hens was a function of environmental temperature, Figure 4. The total quantity produced was low at 50°F, increased to a high at 60° and 70°F, and declined as the temperature approached 100°F. The reasons for the high dust production at 60° and 70°F and the lower dust production at 50° and 100°F are not clear. At the lower temperature, the birds were more active; consequently, they might be expected to produce more dust. The biological reason for the reduction in dust at 50°F will require further investigation.

DUST PRODUCTION AND AGE OF LITTER

Studies comparing different litter materials have already indicated that age of litter materials influenced litter dust production, Figures 1, 2, and 3. A continuous study from 0 to 80 days of age for corn cob litter was conducted to further investigate the effect of litter age. As may be seen in Figure 5, the dust production in-

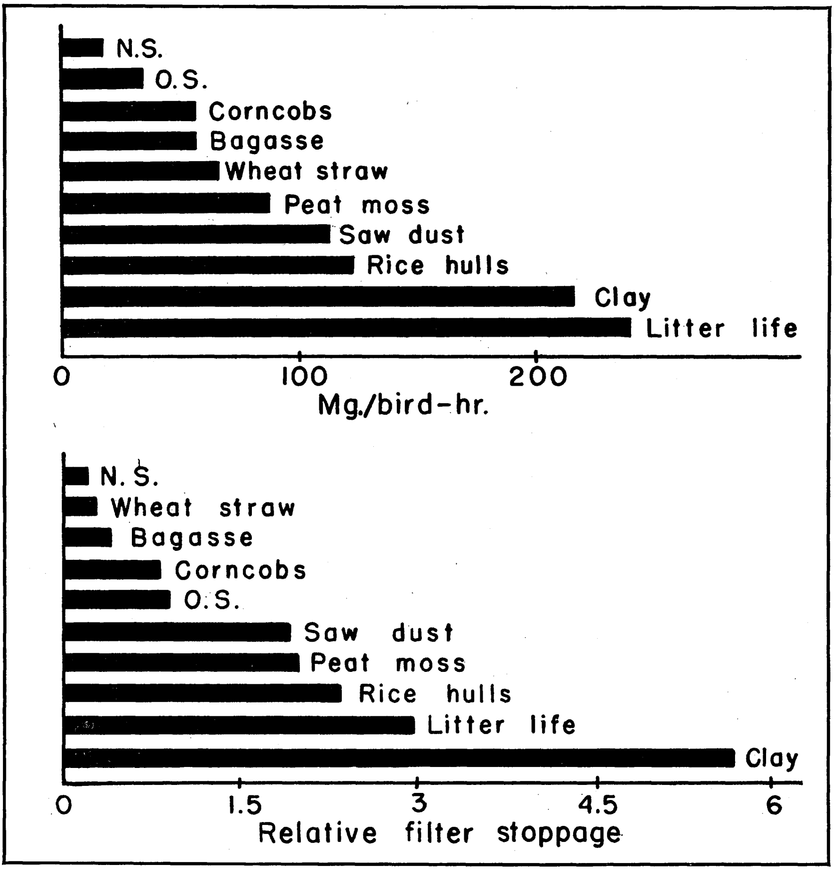

FIG. 3. Daytime dust production from various litter materials at 80°F and 60% relative humidity.

creased until about the seventieth day, after which dust production leveled off. This plateau effect was found to continue thereafter. The time taken to reach the plateau varied for each litter material investigated depending upon the rate at which the particles of the material became pulverized by the action of the birds. This pulverizing effect depended on bird density and activity. The latter factor also depended heavily upon the amount and intensity of illumination offered to the bird.

DUST PRODUCTION, ILLUMINATION, AND HUMIDITY

Dust data collected from hens that were kept on floor litter are presented in Figures 6, 7, and 8. Specific data relating to dust production are confined to new and 6-month-old yellow-pine

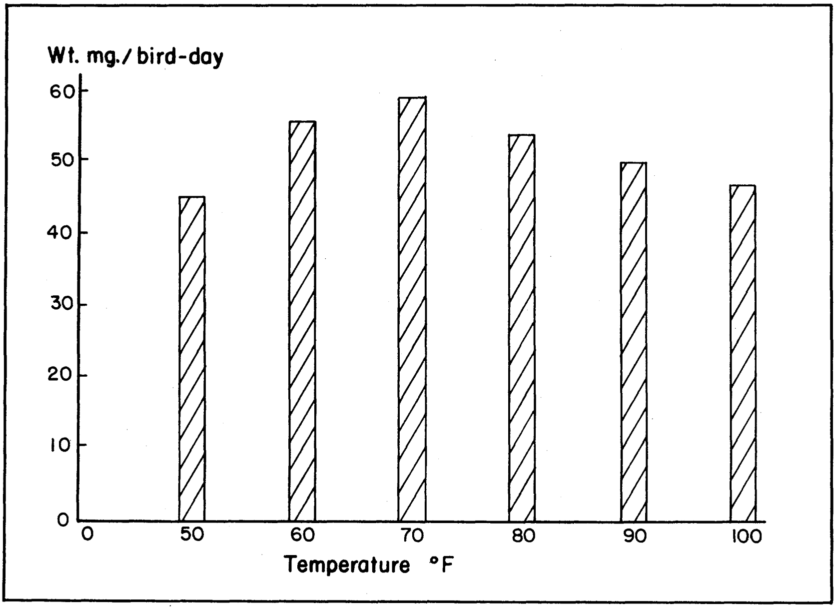

FIG. 4. Airborne dust production from caged hens maintained at constant environmental temperatures.

shavings litter. The basic assumptions drawn from these data also apply to those obtained from the peat moss and clay litters.

The data on the air in chambers involving new and old shavings litter, Figures 6 and 7, indicated that dust was a function of relative humidity. The quantity produced was greatest at the lowest humidities and declined at a uniform rate as the relative humidity of the air increased to 70 per cent. Relative humidity of the air was reflected in the percentage of moisture in the litter. This increase in litter moisture was probably the major reason for reduction of dust at the higher humidity levels.

Bird activity is reflected in the difference between dust produced in periods of illumination and darkness, Figures 6 and 7. Possibly the major source of dust during periods of darkness was dust that had accumulated on the feathers and body of the birds and was dislodged by small body movements during the periods of rest. Since it was held in the feathers, this dust was probably affected less by air moisture than by litter; therefore, the difference between high and low air humidities was less pronounced.

Not all dust that became airborne as a result of bird activity remained suspended until exhausted. Some of this dust, Figure 8, returned to the litter and other surfaces within the animal

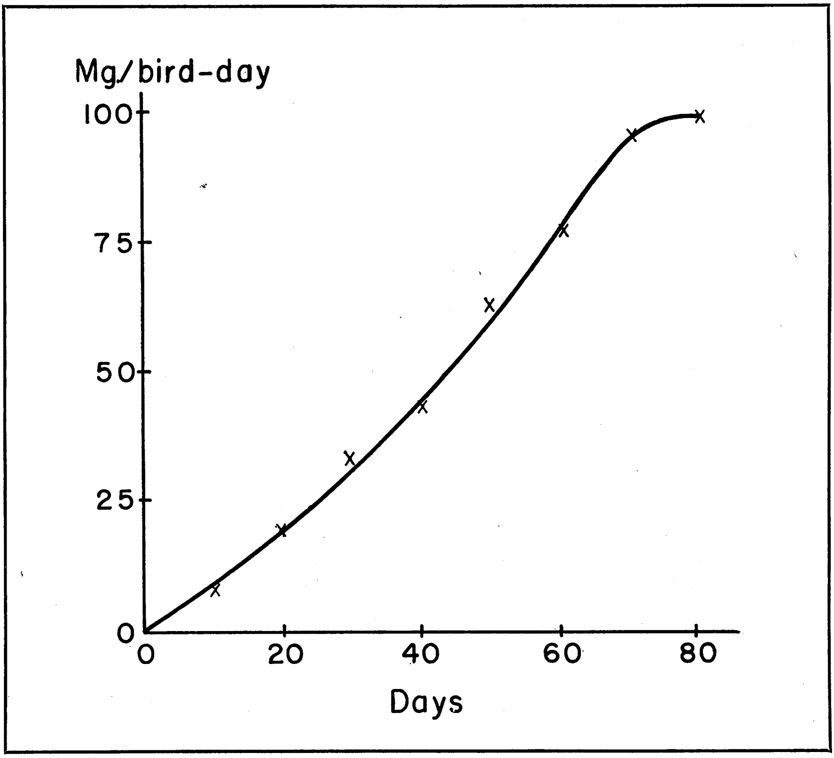

FIG. 5. Daytime dust production from corn cob litter at 80°F and 60% relative humidity.

area. This dust was also influenced by air moisture and varied with exposures to light as a result of increased bird activity. A comparison of Figures 6 and 8 illustrates the difference in quantity of dust that was held in suspension and was deposited back to the litter. A point of interest in Figure 8 is the uniform difference between the dust collected in periods of illumination and darkness at the different levels of relative humidity. This was contrary to the results for airborne samples shown in Figures 6 and 7, and the reason for this difference is not apparent.

The effect of illumination on the dust production for various litter materials was further emphasized by the data shown in Figure 9. Daytime dust was invariably higher during periods of light, indicating a close association with bird activity.

The interrelationships of humidity and daytime dust production are illustrated in Figure 9. Dust production was lower at 50 per cent as against 40 per cent relative humidity for all litter

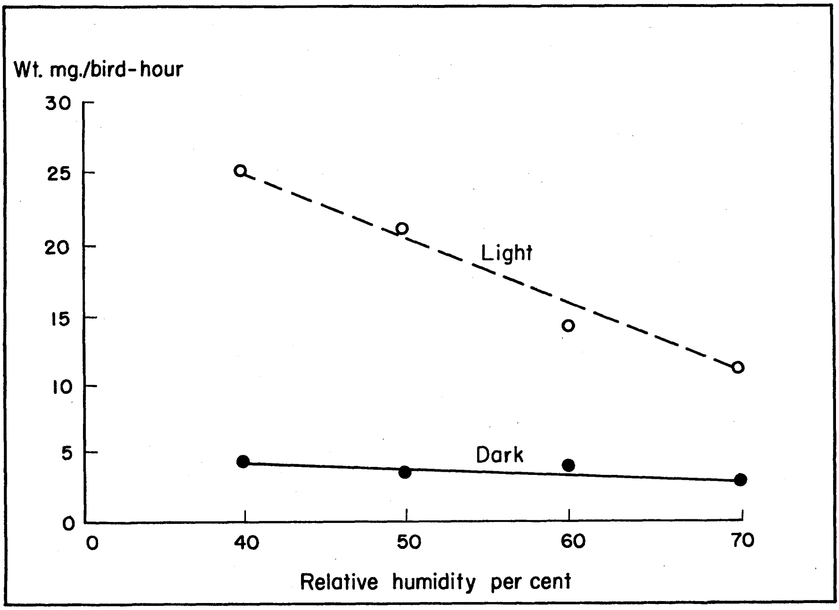

FIG. 6. Airborne dust production from fresh pine shavings during periods of light and darkness and at various humidities.

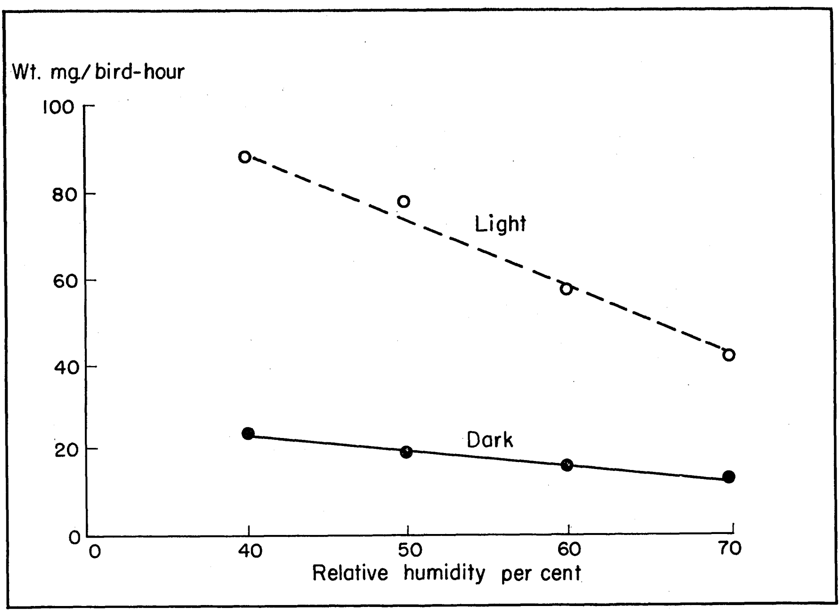

FIG. 7. Airborne dust production from 6-months-old pine shavings during periods of light and darkness and at various humidities.

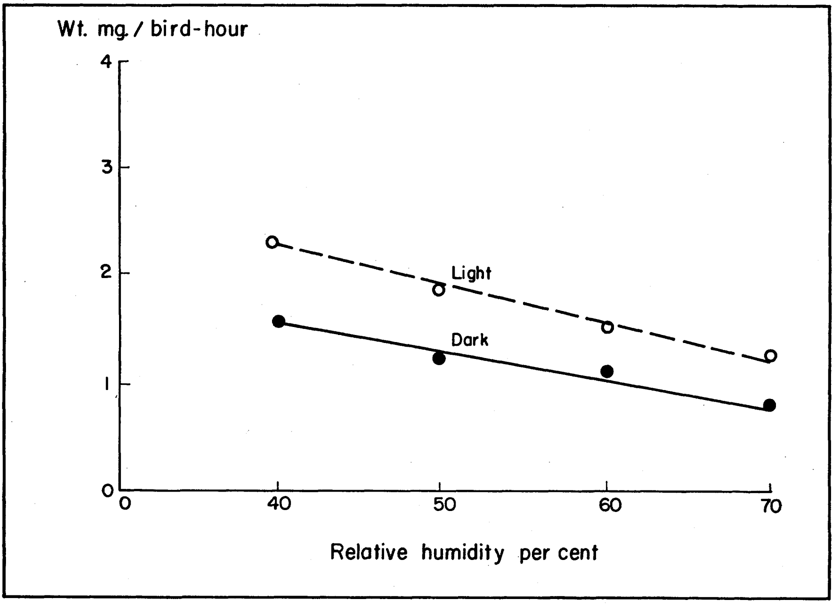

FIG. 8. Settled dust production from fresh pine shavings during periods of light and darkness and at various humidities.

materials except peat moss and sawdust. The results for sawdust were approximately the same for both humidity levels. Peat moss in other experiments has been shown to require a much higher relative humidity (70 per cent) to reduce airborne dust. Thus, in any litter system where peat moss is a major ingredient, high relative humidities are required to reduce dust.

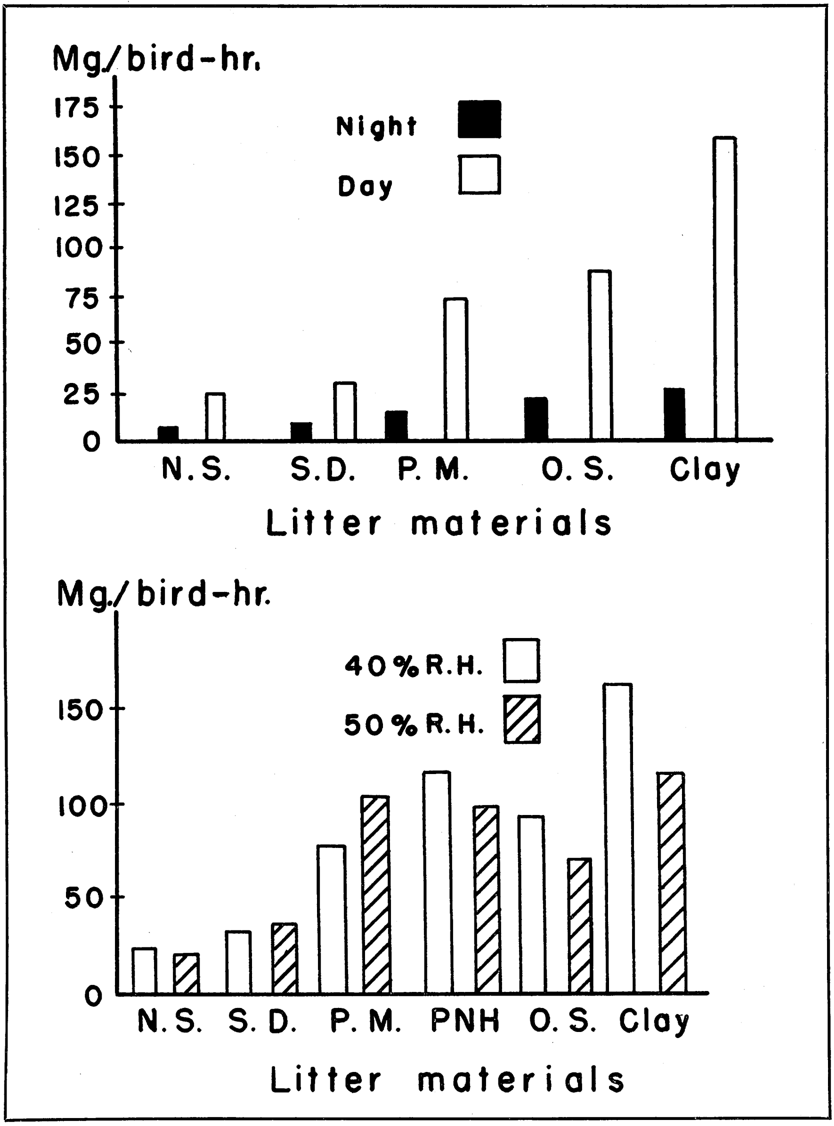

FIG. 9. Daytime dust production from various litter materials during periods of light and darkness and at two different humidities.

CONCLUSIONS

In studying dust production in poultry houses, it is essential to consider several factors which greatly influence dust production. These include:

1. Type of birds.
2. Age of birds.
3. Breed and strain of birds.
4. Form in which feed is offered.
5. Method of housing; cages or floor systems.
6. Density of floor-housed birds.
7. Type of litter material.
8. Age of litter material.
9. Illumination schedule and bird activity.
10. Atmospheric humidity.
11. Environmental temperature.
12. Ventilation system and filter system if air is recycled.

In making comparisons of dust production, airborne dust is probably a better form of estimating dustiness than measurements of dust produced per bird per day or of settled dust.

Based on studies to date, pine shavings as a litter material is highly desirable, but other materials such as chopped corn cobs or wheat straw, rice hulls, or bagasse have desirable features.

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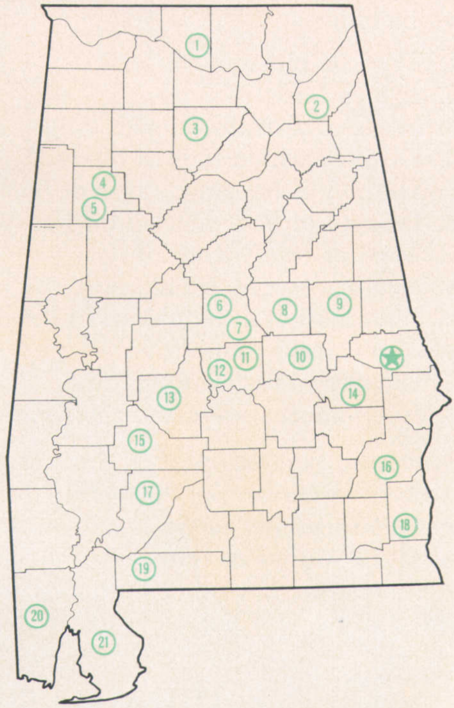

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
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