MOISTURE PRODUCTION OF GROWING TURKEY POULTS

by

Kurt Bachman

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APPROVED:

J. P. H. Mason, Jr., Chairman

A. T. Leighton, Jr.

B. H. Bingham

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Finally, most valuable during the duration of this project were the encouragement and love expressed by my wife and daughter,

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INTRODUCTION

The shift from range growing to confinement growing of turkeys in Virginia began in the mid 1960's. Today, 1972, approximately 50% of the total number of turkeys are raised in confinement, whereas, in 1969 this figure was 30% (1,2).* This trend is expected to continue as it is becoming necessary for growers to supply processing plants with a more balanced input of birds throughout the year.

The turkey is a functioning biological system and can be expected to react adversely when environmental conditions are not optimum. Relative humidity and temperature are the important environmental factors affecting the growth and performance of turkeys (3). In order to control the relative humidity within a building, though, data on the moisture production of poultry are needed.

Much emphasis has been placed upon providing the engineer with sufficient moisture production data for designing the optimum environment for chickens. For turkeys, however, data are inadequate but are very much needed in light of the increased confinement trends in turkey production.

Bingham (2), at the Virginia Polytechnic Institute and State University Turkey Research Center, developed a testing procedure which has been successfully used to determine the moisture production of some classes of turkeys. These facilities were equipped to control environmental temperature and lighting. The respired moisture production was

*Numbers in parentheses refer to appended references.

determined from the psychometric properties of the inlet and exhaust air. Fecal moisture was determined by oven drying fecal samples. Furthermore, these measurements of moisture production were verified by the use of a moisture balance, i.e., all of the water that a turkey gains through the feed and water consumed must be discharged by the bird in some other form, assuming no change in body weight.

Bingham's facilities produced valid results (2,4) but were limited to the use of grown turkeys. However, turkeys are normally placed in the growing house at approximately eight weeks of age and left there until near maturity at about eighteen weeks of age. The moisture production for the young birds is not necessarily the same as for older birds, thus, additional data for growing turkeys are needed. For a growing turkey, moisture is received in the same manner as for full grown turkeys, but the release of water by the growing turkey is slightly different since body weight is constantly increasing. Some of the water released by the growing turkey is discharged through the fecal material, some is respired, and some is transported to the body tissues as a part of the growth process. The basic concept of a moisture balance, however, holds for growing as well as for grown turkeys.

This investigation determined the moisture production of a group of growing turkey poults by using the same basic facilities developed by Bingham. However, some alteration of these facilities to adapt them to turkey poults was first necessary.

It is felt that the knowledge gained from this study will allow a more optimum ventilation system to be designed for confinement grown turkeys.

REVIEW OF LITERATURE

Data on the moisture production of turkeys are inadequate (5). Nearly all of the research done on the moisture production of poultry has been with chickens. In 1953, Ota *et al.* (6) developed a calorimeter which was used to determine the heat and moisture production of laying hens. This calorimeter was subsequently used by Longhouse *et al.* (7) to determine the moisture production of some commercial breeds of chickens. The data obtained from these studies appear in various publications (2,7,8). By using these data, the approximate amount of moisture which will be produced can be determined, if the feed consumption is known, for the various breeds investigated.

The data from studies which have involved chickens cannot be adequately applied to turkeys. The turkey is a larger bird and remains in the growing house for a longer length of time. In an attempt to fulfill the need for data regarding the moisture production of turkeys, some research has been done. Ota and McNally (5) used a calorimeter, similar to that used on chickens, for a moisture production study of turkeys. Mature male and female Beltsville white turkeys about nineteen months of age were used in their study. In their study, Ota and McNally determined the heat and moisture production for nighttime versus daytime conditions since at nighttime, some modification of environmental controls may be necessary to compensate for the smaller amounts of heat and moisture being produced.

In 1969, Bingham (2), with the use of the facilities developed at the Virginia Polytechnic Institute and State University Turkey Research Center, determined the moisture production of a group of mature laying turkeys subjected to different environmental temperatures. Fecal material production declined with increasing temperature for both groups of birds used by Bingham. Respired moisture production, however, increased with higher temperature since at higher temperatures, a greater amount of moisture is respired as a result of the temperature regulation in the bird. Frazier (4), in a similar experiment, determined the moisture production of mature male turkeys subjected to different environmental temperatures and obtained results similar to those reported by Bingham.

All of the heretofore mentioned studies involved the use of a moisture input and output balance which was used as a check on the accuracy of the results. This moisture balancing technique is valid since an animal must regain exactly all of the water that it loses if it is to maintain its normal water content (4). Considerable research has been done to determine how much moisture is received by domestic fowl such as turkeys (5,10) and how the moisture is later released.

Moisture Input Measurements

Ota has consistently used the figure of 54 percent of the weight of the feed consumed to describe the total free and metabolizable water of the feed (5,6,7,10). This figure was developed by Mitchell and Kelley (10) and assumes a normal moisture content of the feed of approximately 10 percent, wet basis (5). Indications are, however, that this figure of 54 percent varies with the age of bird, diet, species, and plumage (11), but to the author's knowledge, no data are available on how this figure varies. The input moisture, therefore, was determined by summing the total weight of the water consumed from the fountain and 54 percent of the weight of the feed consumed.

Moisture Output Measurements

All of the water which is consumed by a growing turkey must either be transported to the tissues to further the growth process or be otherwise eliminated from the body system. There is substantial evidence that birds do not have sweat glands, therefore, no moisture is lost by sweating (9). Moisture is released by birds, however, through the fecal material and through respiration.

Fecal Moisture

Fecal moisture constitutes the largest release of moisture by the bird (12). The fecal material, as defecated, contains 80 percent moisture on a wet weight basis (13). Ota *et al*. (14) and Bingham (2) effectively separated the fecal moisture from the total moisture produced by catching all of the bird droppings in collection pans filled with water and covered with a thin film of automotive oil. The collection pans were supported by platform scales for determining the weight of fecal material. In addition, sampling of the fecal material provided a means for moisture determinations.

Respired Moisture

Moisture respired by the turkey results from water added to the inspired air during respiration. This moisture is a result of the heat regulation in the bird and is, in effect, evaporated from the surface moisture in the respiratory passageways (9).

Bingham (2) designed, developed, and used a facility at the Virginia Polytechnic Institute and State University Turkey Research Center that allowed the measurement of the respired moisture produced by a pen of turkeys. Frazier (4) also used the same facility. In general, saturated air at a known temperature and at a measured rate of flow was introduced into a chamber containing the pen which housed the birds. Relative humidity of the exhaust air was measured. The difference between the incoming and outgoing specific humidity was taken as the moisture production when related to the rate of air flow. Sources of moisture other than respiration were controlled. Fecal production, feed and water consumption, bird weight, and egg production were determined. The bird chamber temperature and humidity were controlled by regulating the rate of flow and temperature of the incoming air and by using heating and cooling equipment in the space surrounding the bird chamber. Bird weight measurements were determined by catching and weighing the birds; considerable disturbance to the birds resulted. Similarly, the measurement of the flow rate of air with a hot wire anemometer disrupted established air flow in the bird chamber. Bingham (2) and Frazier (4) both recommended that improvements be made in the air flow rate measurements and bird weighing techniques.

OBJECTIVES

There were three specific objectives for this investigation:

1. Revision of Bingham's facilities to accomplish the following:
    a. Provide air flow measurements exterior to the plenum chamber thus not disturbing the established conditions in the bird chamber.
    b. Provide a system of group weighing the birds to eliminate major bird disturbance.
2. To determine the fecal and respired moisture production of a group of sexed turkey poults during the grow-out period.
3. To evaluate the use of the revised facilities in determining the moisture production of turkey poults.

THE INVESTIGATION

Basic Assumption

Ota *et al.* (5) used the same procedure and equipment for studying the moisture production of turkeys as were used for studies conducted on chickens. The other investigators that have determined the moisture production of turkeys assumed that the chicken and turkey are physiologically similar (2,5). The same assumption was made in this investigation.

Description of Bingham's Modified Facilities

Schematically, the revised facilities are shown in Figure 1. Air entered the saturater and passed through a fine water-mist spray. Contact between the air and water spray was promoted by the sinuous motion of the air as it was forced through the saturater. From the saturater, the air passed into a refrigerated plenum chamber where the air temperature was decreased. This temperature reduction assured air saturation. Saturation was verified, on occasion, at entry to the bird chamber by measuring wet bulb temperature; dry bulb temperature at the same point was monitored. By maintaining saturated air of a known temperature at entry to the bird chamber, specific humidity was calculated precisely.

The saturated air entered the bird chamber and was distributed throughout. Respired moisture from the birds was picked up by the ambient air. At the exit duct, the relative humidity of the exhaust air was measured. Respired moisture production was determined by the

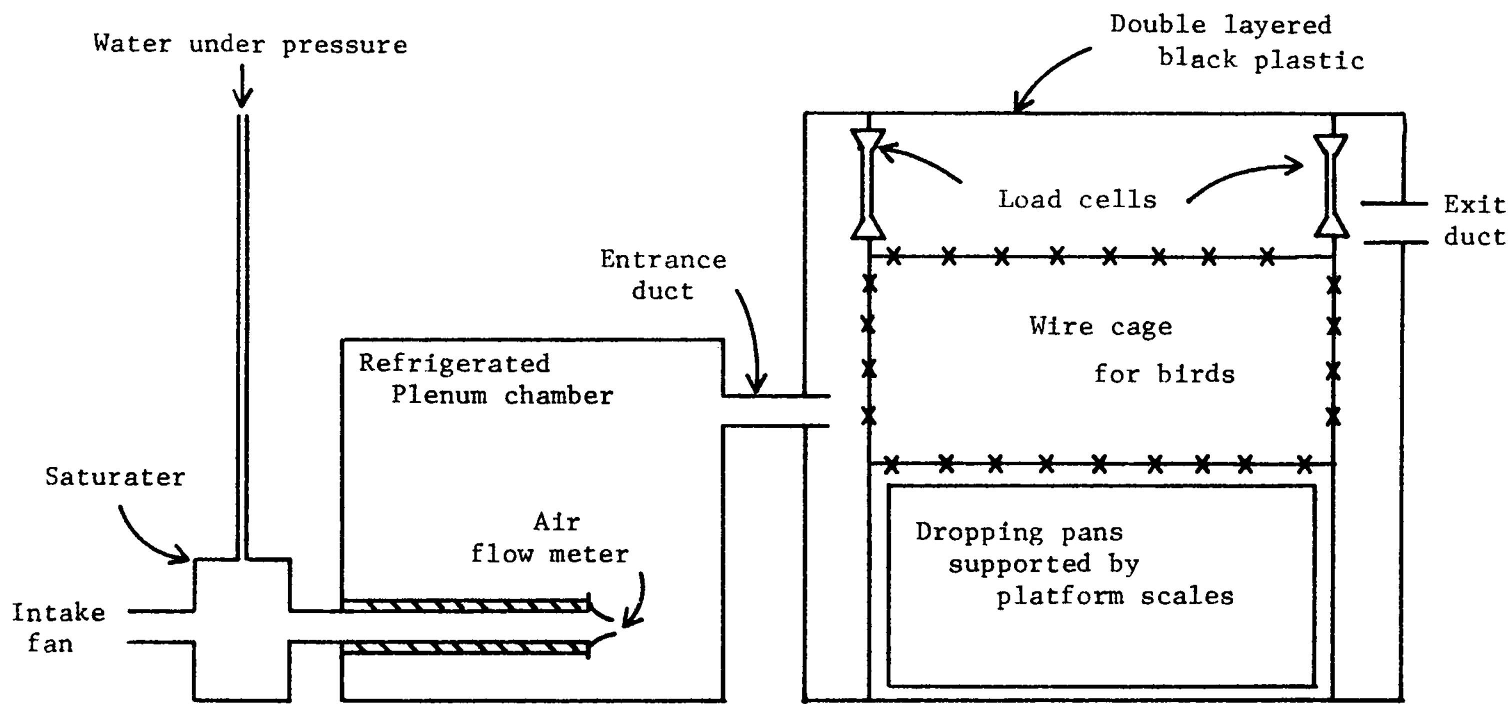

Figure 1. Schematic diagram of the revised facilities used in the investigation.

difference in specific humidity at the entry and exit chamber openings and by measurement of the air mass flow rate.

Fecal moisture was effectively separated from the total moisture produced by collecting the droppings in water with a thin oil film to prevent evaporation. Platform scales were used to weigh the collected material; samples were collected for moisture analysis.

Bingham (2) determined bird weights by periodic removal and weighing of the birds. In addition, air flow measurements were determined by entering the plenum chamber and using a hot wire anemometer at the entrance duct. To improve the facility, a flow meter was introduced near the throat of the saturater to provide flow rate measurements. Load cells were installed on the bird cage to provide bird weight data.

Bird Procurement and Investigative Treatment

Birds used in this investigation were hatched from medium white stock reared at the Turkey Research Center. Wing banding provided the means of identification of the day-old poults. Females, because of their more docile nature were used. During the standard six week brooding period, the poults were kept in temperature-controlled starter batteries; mortality was followed closely.

The number of poults needed for this investigation was determined by allowing 1.6 square feet of cage floor space per bird (15). The floor space of the cage was approximately 48 square feet, thus, thirty birds were used. At hatch time, eighty poults were reserved to insure at least thirty healthy and uniformly sized poults at six weeks of age.

As a further precaution, a separate pen was established to house several extra poults in case they were needed. All crippled and otherwise sick birds were removed from the investigation and replaced with healthy birds from the reserve population.

The entire investigation was conducted at an environmental temperature of 70°F. This temperature is in the range of thermoneutrality for the turkey as reported by several investigators (16,17), and is a desirable temperature for the grow-out period; at temperatures in the thermoneutral range of the turkey, feed conversion is best (17).

In keeping with recommendations and the lighting treatments applied by other investigators (2,4,5,15,18), a light:dark period of sixteen hours of light and eight hours of dark was used. One sixty watt incandescent lamp supplied approximately three foot-candles of illumination at the floor level of the bird cage.

Data Procurement

Moisture Input Measurements

Both feed and water were measured daily at approximately the same time of day. Weighings were done on a set of Toledo gram scales (Toledo Scale Company, Model #4030) shown in Figure 2. Fifty-four percent of the weight of the feed consumed was used throughout this investigation to describe the free and metabolizable water derived from the digestion of the feed; no other figure is available to describe this percentage (11).

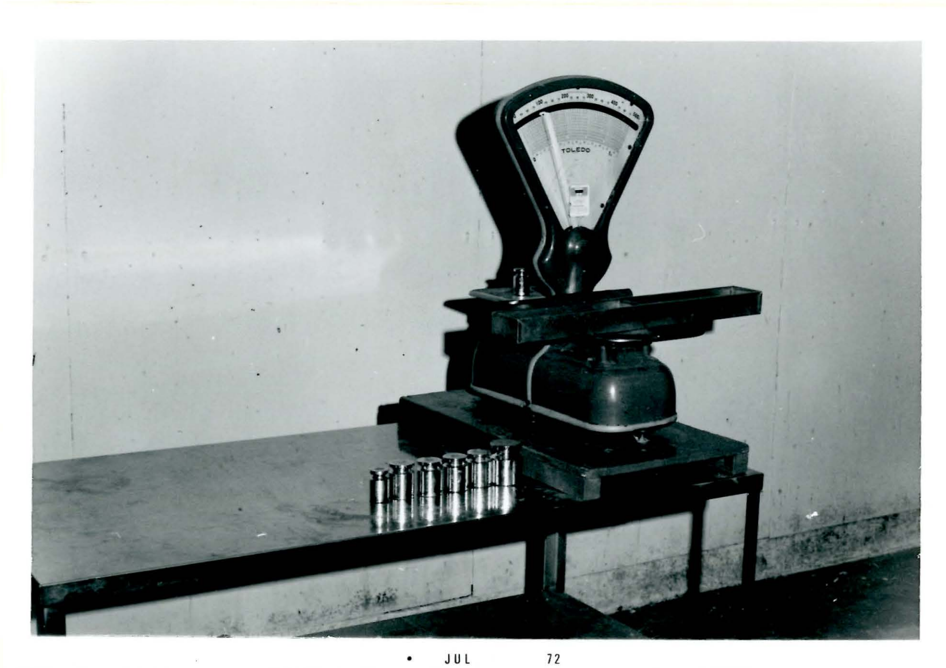

Figure 2. Toledo gram scales used to weigh the feed and water input. These scales had a capacity of 5000 grams with an accuracy of 1 gram.

Moisture Output Measurements

The measurement of the moisture output was considerably more involved than the measurement of the moisture input. The moisture output was determined during a 48-hour test period; there was one test period corresponding to each week of the grow-out period. The moisture input was balanced against the output for each of the test periods to check accuracy and allow observing the physiological performance of the birds.

Fecal Moisture. Three 18 in. x 18 in. x 8 ft collection pans supported at the ends by platform scales allowed weighing the amount of fecal material eliminated by the birds over a period of time. Due to the relative insensitivity of the platform scales, fecal material weighings were taken only at the beginning and the end of a test period. For moisture determinations, one 6 in. x 6 in. x 22 in. fecal sampling pan was placed on top of the collection pans; the pan was filled with water and covered with a thin film of oil. After allowing ample time for a sample to accumulate in the pan, it was removed from the test chamber, weighed and oven dried at 80°C. Weighings of the fecal sample during the drying period were done on an Ohaus scale (Ohaus Scale Corp., Model 1201 Harvard Trip Balance) which had an accuracy of 0.1 grams.

Respired Moisture. To determine the respired moisture, it was necessary to control the inlet air conditions as much as possible. The air flow temperature, and environmental temperature and relative humidity were known and held constant throughout a test period.

The air flow rate was measured using a standard ASME flow nozzle (manufactured to specifications by Able Metal Spinning and Stamping Company, Far Rockaway, New York) and an inclined tube differential manometer (E. Vernon Hill, Inc., Lake Geneva, Wisconsin) with a readability of 0.001 inches of manometer fluid (specific gravity = 0.797) pressure differential. The flow rate was computed according to a flow equation for nozzles established by the American Society of Mechanical Engineers Research Committee on Fluid Meters (19). The design and selection of the nozzle are covered in Appendix I. The plenum chamber interior showing the flow nozzle attached to the end of insulated piping is shown in Figure 3. The inclined tube differential manometer is shown in Figure 4.

Measurement of the relative humidity and temperature of the exit air determined the specific humidity of the air. Thus, every precaution was taken to insure that air could exit in only one location. This was accomplished by sealing the doors of the bird chamber tightly and occasionally checking the double-layered-plastic chamber walls for leaks.

All temperatures were measured with copper-constantan thermocouples connected to a multipoint recording potentiometer shown in Figure 5. The temperatures which were recorded by the potentiometer are as follows:

1. temperature of the air entering the flow nozzle
2. temperature of saturated air in entrance duct.
3. temperature at rear of bird cage.

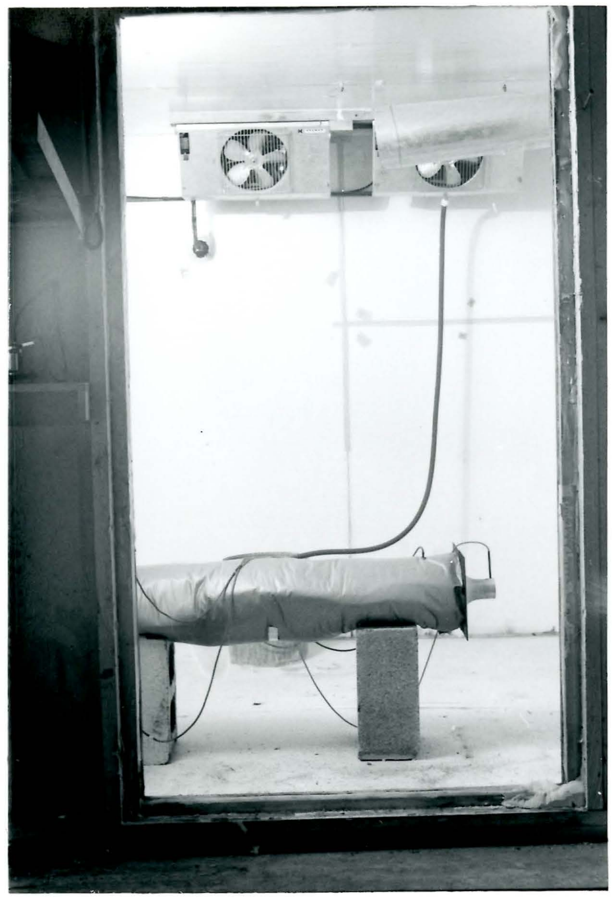

Figure 3. Plenum chamber interior showing a portion of the insulated piping preceding the flow nozzle. The vinyl tubing attached to the pressure taps leads directly to the differential manometer.

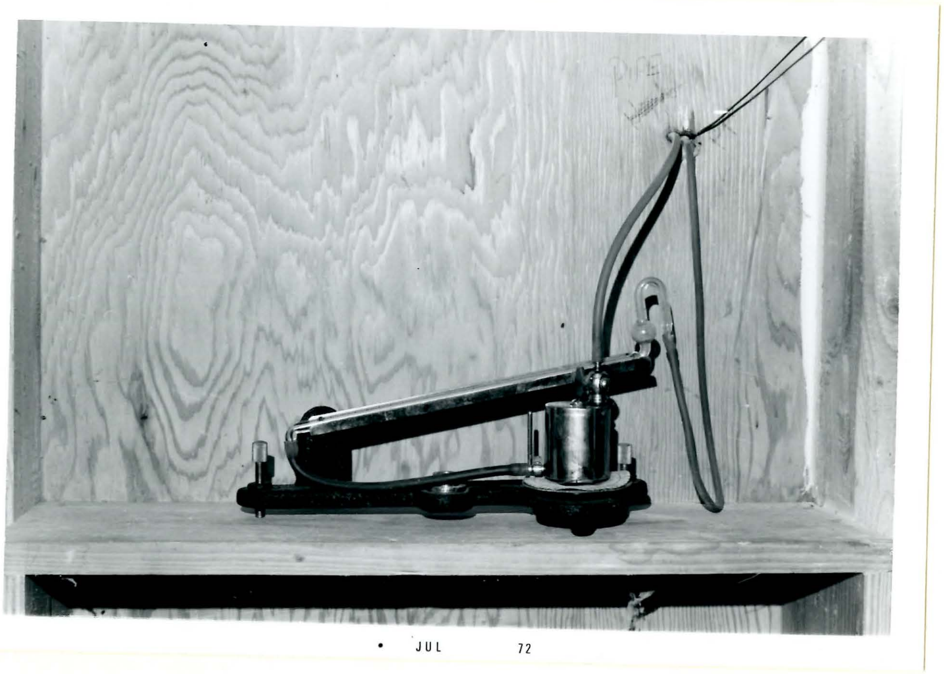

Figure 4. Inclined tube manometer used for measuring the differential pressure across the flow nozzle. Vinyl tubing is also shown exiting from the chamber walls.

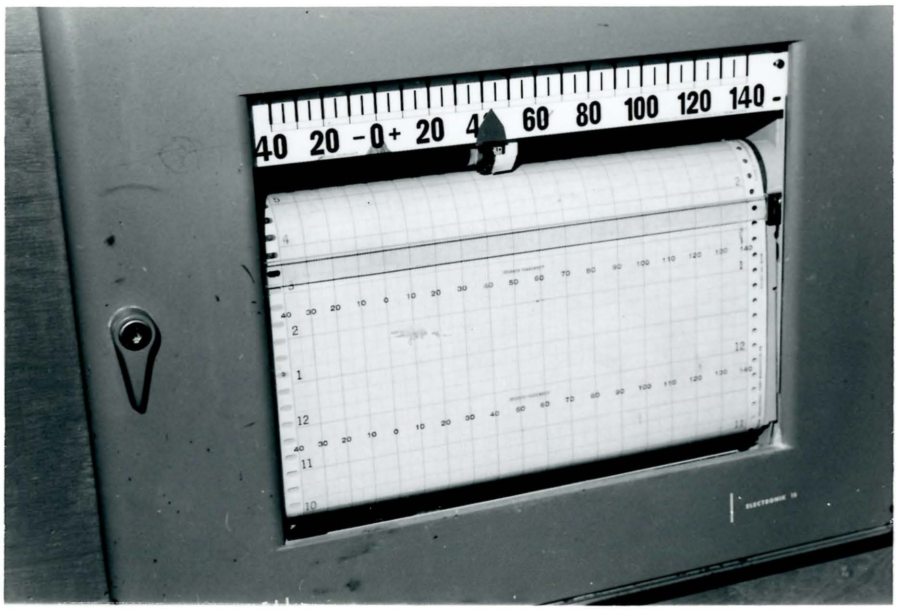

Figure 5. Honeywell multipoint recording potentiometer used for temperature measurements.

4. temperature at front of bird chamber.

5. temperature of the air in exit duct.

6. temperature of the air surrounding bird chamber.

The relative humidity of the exit air was measured with an electric hygrometer-indicator (Hygrodynamics, Inc., Electric Hygrometer-Indicator Model #15-3001), a precise instrument employing lithium chloride sensing elements. The hygrometer-indicator is shown in Figure 6.

Data to allow determining the rate of respired moisture production during light hours was taken according to the data acquisition schedule shown in Appendix II. Similarly, data were taken to allow the determination of respired moisture production during dark hours. Once these determinations were done, the rate of respired moisture production during light hours was compared to that produced during dark hours.

<u>Bird Weighing</u>. Weighing with a minimum of disturbance to the birds was essential since individual weighing was too upsetting to the birds. A group weighing technique was provided by attaching fabricated strain gage load cells on each of the four corners of the cage. The design and construction of the load cells is covered in Appendix I.

The strain gages were wired into four-arm bridge circuits specifically for measuring axial tension (20). These bridge circuits were connected to an Ellis Associates Switch and Balance Unit (Model BSG-6 six channel unit) which was interconnected to a Baldwin SR4 Type M Strain Indicator. Dial readings from the strain indicator were referred

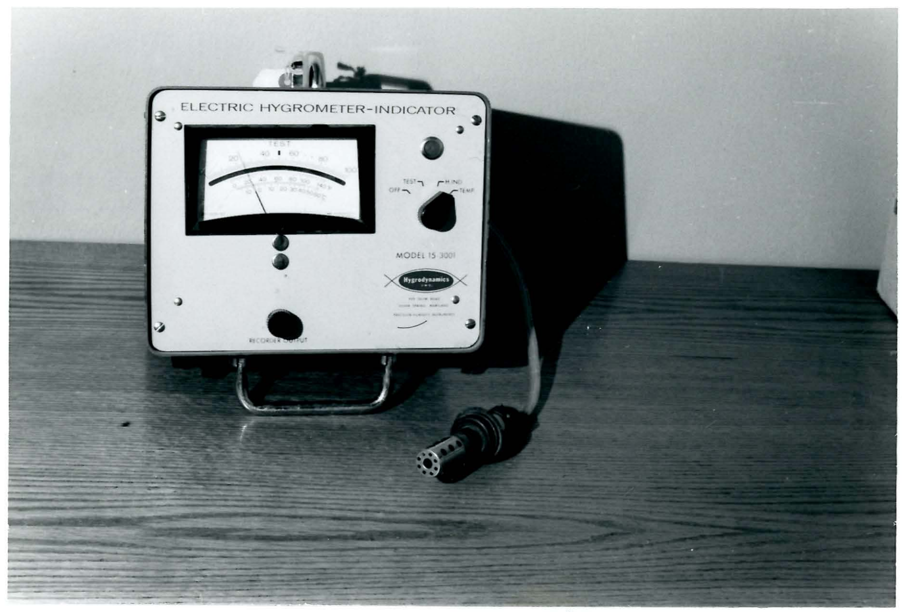

Figure 6. Hygrodynamics electric hygrometer-indicator. In front of the hygrometer-indicator is a lithium chloride sensing element.

to calibration charts constructed for each load cell. The switching unit and strain indicator are shown in Figure 7; fabricated load cells attached to the bird cage are shown in Figure 8.

The change in average bird weight was needed in performing the moisture balance since some of the consumed water is stored in the body during growth. Ota and McNally report that, for turkeys, 65 percent of the body weight increase is water (5). In an attempt to corroborate this figure for use in this investigation, two of the birds from the reserve population were sacrificed and oven dried to determine the body moisture content. Each of the birds was about ten weeks of age and was shown to have a body moisture content of approximately 64.5 percent. These data, as well as data reported by Ota and McNally (5), compare favorably with data obtained from Potter (21) for Beltsville white turkeys from four to six weeks of age. The data obtained from Potter were for turkeys consuming feed containing approximately 30 percent protein. This level of protein was similar to the level contained in the type of feed used throughout this investigation.

Temperature Control Apparatus. Some manipulation of the temperature control apparatus was necessary to maintain the environmental temperature at 70°F throughout the investigation. Partial control of the environmental temperature was rendered through controlling the temperature in the plenum chamber. The limited flexibility of the plenum chamber controls deemed it necessary to rely on other means for

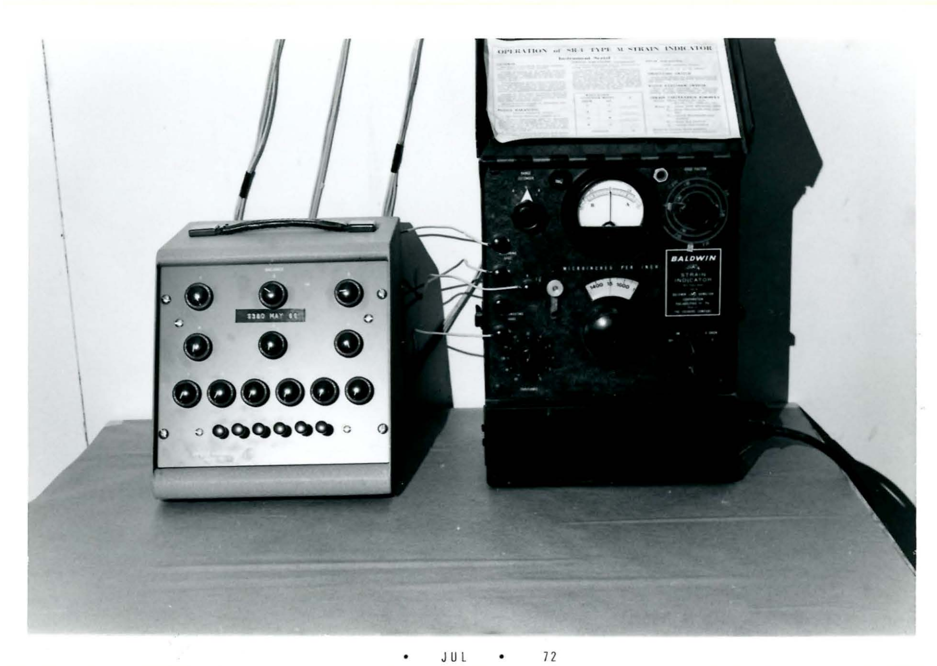

Figure 7. Switch and Balance Unit (left) and Strain Indicator instrumentation used in bird weighing. Wires shown at top left lead directly to the fabricated strain gage load cells.

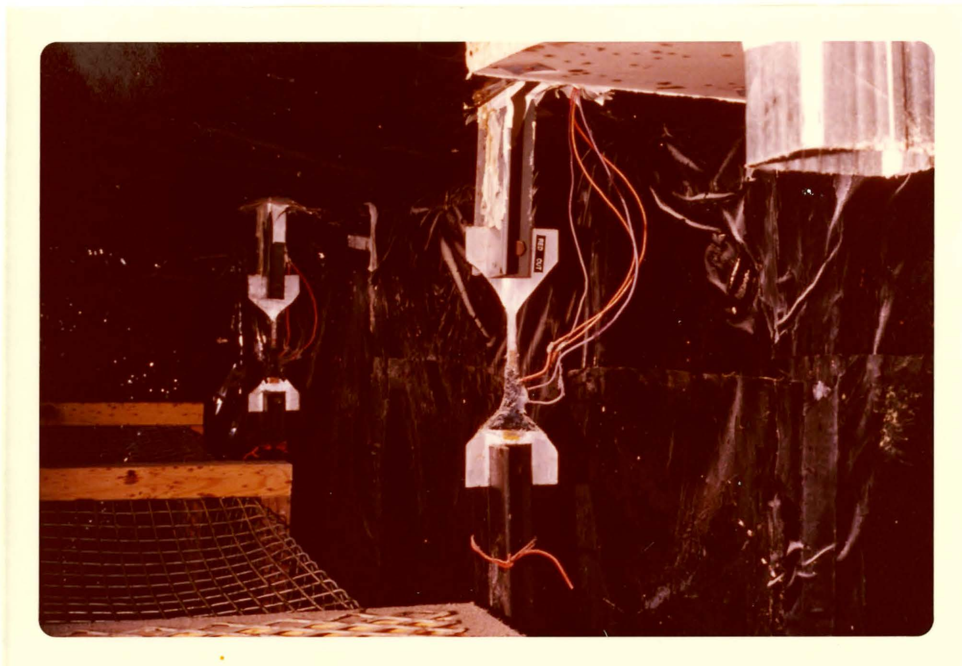

Figure 8. Shown are two of the four fabricated strain gage load cells properly oriented on the bird cage.

controlling the temperature in the bird chamber. Adequate control of the environmental temperature was rendered through the use of an 8-kilowatt electric heater and a 28000 BTU air conditioner. These apparatus functioned well and permitted exacting control of the environmental temperature.

Calibration of Test Equipment

The calibration of all instrumentation and testing apparatus used in this investigation is covered in Appendix III.

Testing Procedure

At the age of six weeks, thirty birds were selected from the population and placed into the bird cage. The temperature in the chamber had previously been set to 70°F so acclimation to the environment began immediately. The lights were permitted to remain on continuously until the birds located the feed and water. Data on feed and water consumption and fecal material production were initiated at once.

Ten days were allowed for proper acclimation to the environment. This length of time seemed more than sufficient as observations of the birds revealed that they were extremely active, ate and drank well, and appeared to adjust very quickly to their new environment.

During the ten day acclimation period, the chamber door was opened once per day during the birds' dark period to simulate disturbance which occurs during weighing. This procedure was necessary since the first attempt at weighing the birds created considerable havoc and made weighing impossible. At the end of the ten day period, test No. 1 was initiated. Data was acquired during each subsequent test period according to the schedule shown in Appendix II.

The investigation ended at the end of test period 12. The birds were then weighed with the load cells, removed from the bird chamber, reweighed on a separate scale and transferred to a market pen.

DATA ANALYSIS

Considerable emphasis was placed upon establishing a data analysis technique to use with the data obtained from each test period. A routine schedule was followed as closely as possible so that each set of data was subjected to exactly the same analysis.

To conform to data presented in literature, the moisture production data were expressed in terms of average bird weight and age. A growth trend curve, therefore, was needed. Prior to the time that the birds were placed into the cage, bird weight data were obtained by weighing the birds on an accurate set of platform scales. After the birds were placed into the cage, the load cells were relied upon to supply the bird weight data. However, as the weight data were plotted, considerable variation was present in the data points. This scatter was finally attributed to the linkage system used to attach the load cells to the bird cage. A stiff piece of angle iron originally connected the load cells to the cage, but a chain link was installed between the thirteenth and fourteenth week of growth. This chain link transmitted no compression to the load cells and resulted in eliminating the variation in the subsequent weighings. Figure 9 shows the growth trend curve and the actual data obtained from the bird weighings. The numbers which appear close to some of the data points signify the number of identical readings at that point; an S signifies a scale reading. The wide scatter in the data points is evident between the ages of 6 weeks and 13 weeks. In order to obtain a uniform curve

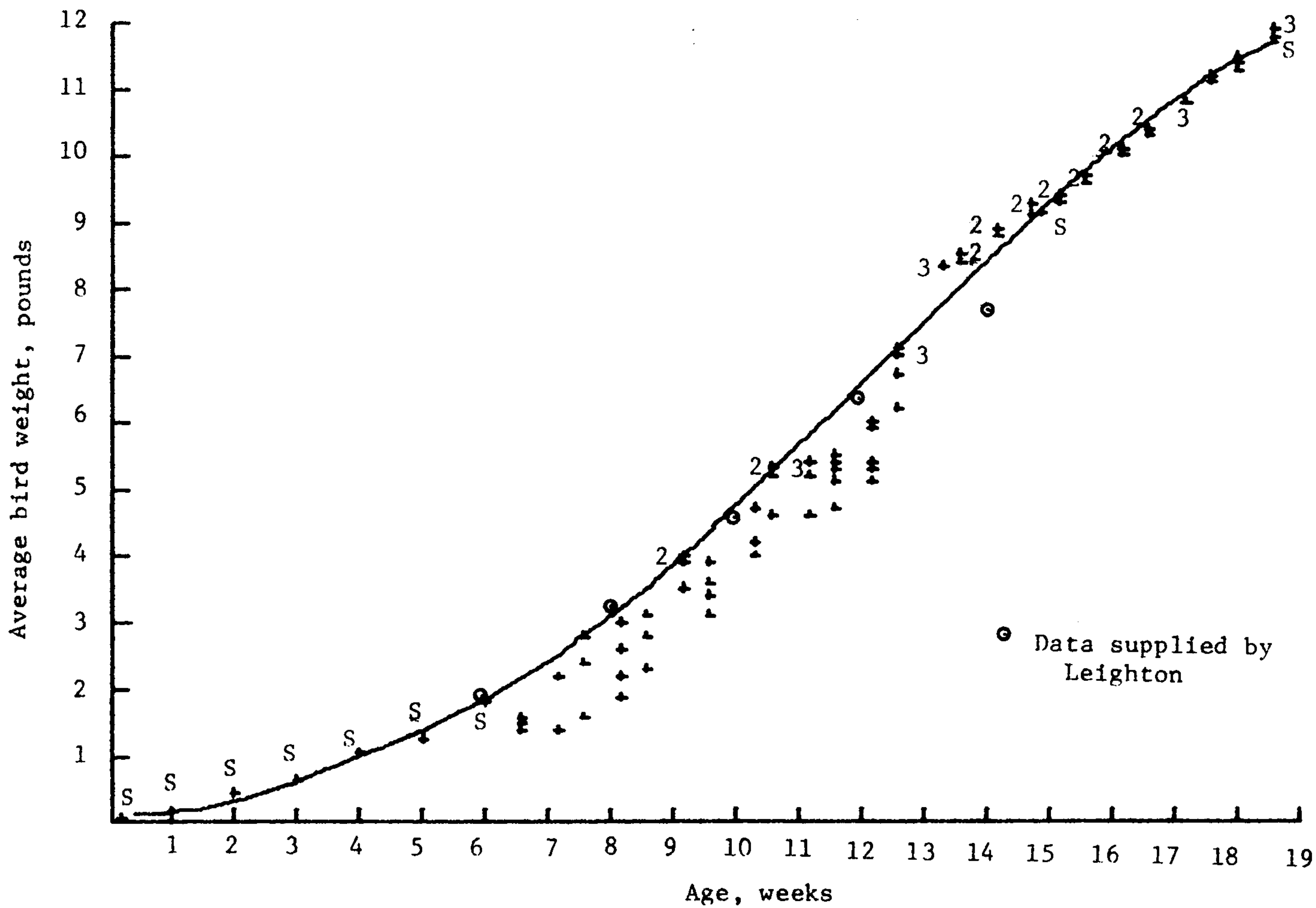

Figure 9. Crowth trend showing actual data and uniform curve of estimated growth. Numbers refer to identical readings at that point; an S signifies a scale reading.

during this period, weight data for medium white females from a controlled environment experiment conducted by Dr. A. T. Leighton, Virginia Polytechnic Institute and State University Poulty Science Department, were plotted. The growth trend curve was then drawn; this curve placed emphasis on the data supplied by Leighton and on the scale and load cell readings during the latter portion of the growth period. All subsequent data analyses presented within were based upon the average weight depicted by the growth curve.

Appendix IV contains the data gathered from this investigation which was used in determining moisture production and performing the moisture balance. The bird weight data shown in this Appendix are data extracted from Figure 9.

Fecal Moisture Data Analysis

The following data are presented for illustrative purposes to demonstrate the analysis used for the fecal moisture production.

Date: November 19, 1971
Time: 3:45 p.m. (beginning of test period)
Platform scale readings:
Front - 1258.0 lbs
Rear - 1161.5 lbs
Total 2419.5 lbs
Sampling pan weight = 4099 grams

Date: November 21, 1972
Time: 3:45 p.m. (end of test period)
Platform scale readings:
Front - 1276.0 lbs
Rear - 1179.0 lbs
Total 2455.0 lbs
Sampling pan weight = 4720 grams

Analysis:

weight of fecal material added to collection pans
=2455.0 - 2419.5 lbs
=35.5 lbs

weight of fecal sample collected for moisture determination
=4720 - 4099 grams
=621 grams (1.37 lbs)

Total weight of fecal material collected
=35.5 + 1.37 lbs
=36.87 lbs

moisture content of fecal material (determined from oven drying of sample)(test period 6) = 0.852

weight of moisture discharged in fecal material
=36.87 x 0.852
=31.40 lbs

The fecal moisture produced was divided by the length of collection period, average weight per bird, and the number of birds and expressed in pounds of fecal moisture produced per pound of bird per hour. Similarly, the moisture produced was divided by the length of collection period and number of birds and expressed in pounds of fecal moisture produced per bird per hour.

Respired Moisture Data Analysis

The inlet air temperature and the relative humidity of the exit air fluctuated somewhat during the length of the test period. To obtain a representative temperature for the incoming air, recorded temperatures were averaged. Since the inlet air was known to be saturated, the specific humidity was thereby established by reference to a psychometric chart (22). In a like manner, humidity readings of the exit air were averaged and referred to a psychometric chart to determine the specific humidity. The difference between the specific humidity of the exit air and the inlet air is denoted by Δ specific humidity in the following sample calculations for respired moisture.

Dark period 1, 8 hours

Δ specific humidity = 0.00215 lb H_2O/lb dry air

Light period 1, 16 hours

Δ specific humidity = 0.00414 lb H_2O/lb dry air

Dark period 2, 8 hours

Δ specific humidity = 0.00220 lb H_2O/ lb dry air

Light period 2, 16 hours

Δ specific humidity = 0.00418 lb H_2O/lb dry air

Dark period average Δ specific humidity

$$= \frac{0.00215 + 0.00220}{2}$$

= 0.00218 lb H_2O/lb dry air

Light period average Δ specific humidity

$$= \frac{0.00414 + 0.00418}{2}$$

= 0.00416 lb H_2O/lb dry air

Respired Moisture Calculations:

Light periods:

$$= 2.395^{*} \frac{\text{lb d.a.}^{+}}{\text{min}} \times 0.00416 \frac{\text{lb } H_2O}{\text{lb d.a.}} \times 16 \text{ hrs} \times 60 \frac{\text{min}}{\text{hr}}$$

$$\times 2 \text{ periods}$$

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*Air mass flow rate

+Dry air is abbreviated d.a.

$= 19.15$ lbs of water respired during 32 hours of light

Dark periods:

$= 2.395 \times 0.00218 \times 8 \times 60 \times 2$

$= 5.03$ lbs of water respired during 16 hours of dark

Percent diurnal variation:

$$= \frac{0.00416 - 0.00218}{0.00218} \times 100 = 91\%$$

Total respired moisture:

$= 19.15 + 5.03$ lbs

$= 24.18$ lbs

To express the data in a manner similar to other investigators, the respired moisture production was expressed both as pounds of moisture respired per pound of bird per hour and as pounds of moisture respired per bird per hour.

The following is a typical calculation to determine the average bird weight and the amount of water in the total weight increase.

Total bird weight at beginning of test period

$= 78.20$ lbs

Total bird weight at end of test period

$= 84.90$ lbs

Average bird weight at end of test period

$$= \frac{78.20 + 84.90}{2} \div 30$$

$= 2.72$ lbs per bird

Amount of water contained in total weight increase

$= 0.65 \times (84.90 - 78.20)$ lbs

$= 4.35$ lbs

RESULTS AND DISCUSSION

Evaluation of Revised Facilities

The standard flow nozzle installed to meter the air flow rate from the saturater into the plenum chamber provided a means for convenient and effective remote air flow measurement. The plenum chamber was sealed prior to the initial test and remained undisturbed throughout the investigation. The nozzle allowed easy data collection with sufficient accuracy as discussed in Appendix III. Furthermore, the air flow measurement technique did not interrupt the continuous flow of saturated air into the bird chamber.

Bird disturbance was eliminated during weighing by the use of the fabricated load cells. However, the weighing could be done only while the lights were completely off in the bird chamber and surrounding room. In this manner, provided that the lights had been off for several hours prior to weighing, the birds were calm and were easily weighed as a group.

The addition of the chain linkage was a highly important factor leading to the repeatability of readings. Accuracy of the load cells was ascertained by extracting the birds from the cage and weighing them on a separate set of scales. Less than 1 percent difference between the scale readings and the load cell readings was achieved.

Overall, the facilities operated with little difficulty. There was adequate flexibility of the controls to accommodate medium white females for the grow-out period, assuming a constant environmental temperature throughout. Should a different class of birds be used or a fluctuating environmental temperature be desired, some manipulation of the temperature controls will be necessary. Otherwise, the facilities are satisfactory for moisture production measurements.

Presentation of Results

Regression analyses, with the aid of computer programs, were performed on the data to determine the best fit equation. Validity of the computer programs was checked with hand calculations. In addition, correlation coefficients, to describe how well the data fit the regression curve, were determined. The best fit equation and correlation coefficient, r, are shown on each of the graphs that follows.

The usefulness of the data obtained has been expanded by expressing both the fecal and respired moisture production in the following two ways:

1. Moisture production per pound of bird versus age.
2. Moisture production per bird versus average bird weight.

Fecal Moisture Production

Figures 10 and 11 present the rate of fecal moisture production per pound of bird versus age and the rate of fecal moisture production per bird versus average weight, respectively. Table 1 shows the rate of feed and water consumption per pound of bird as it related to age and average bird weight.

Respired Moisture Production

Figures 12 and 13 present, respectively, the rate of respired

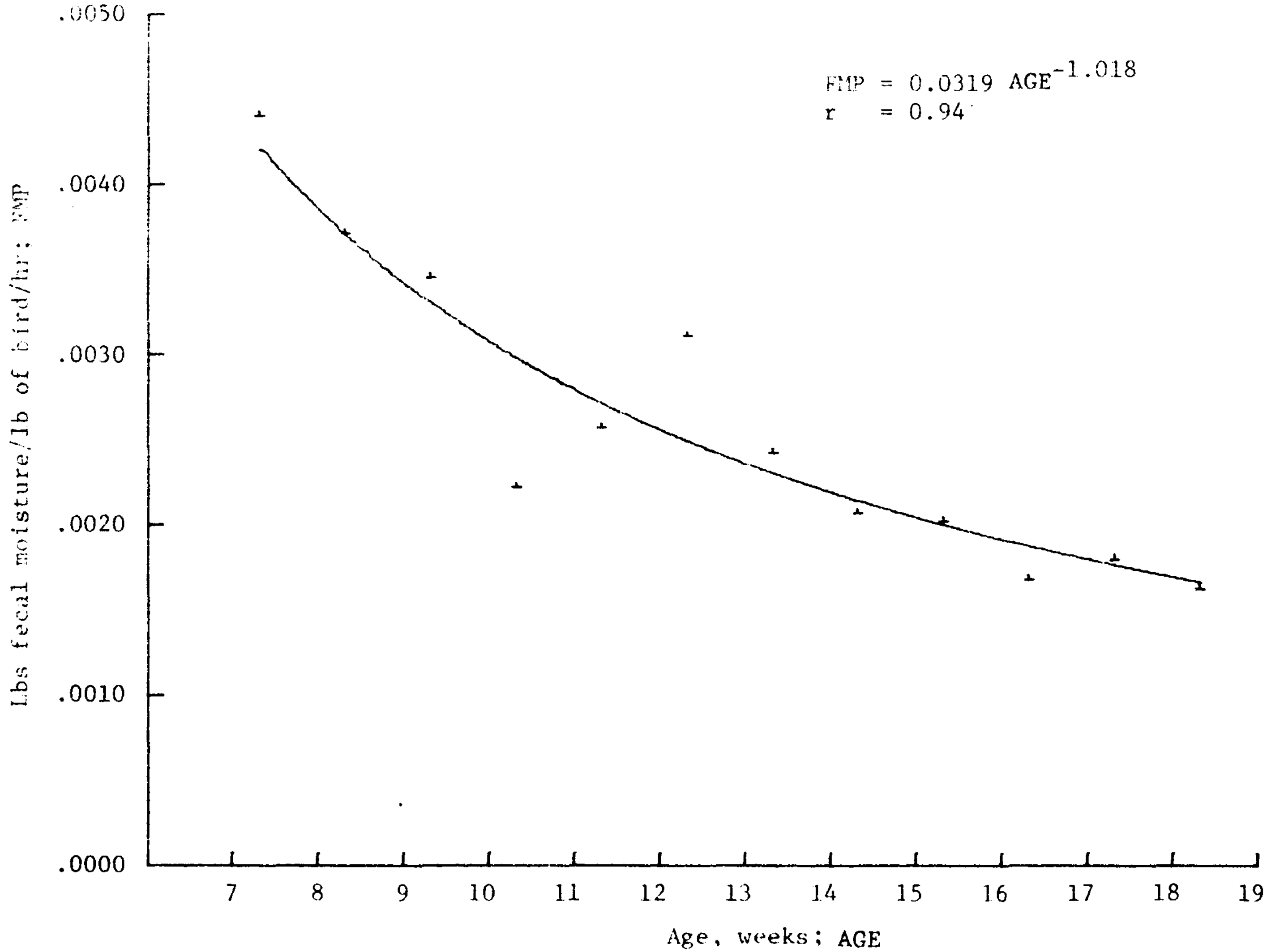

Figure 10. Rate of fecal moisture production per pound of bird versus age. Also shown are the best fit equation and correlation coefficient, r.

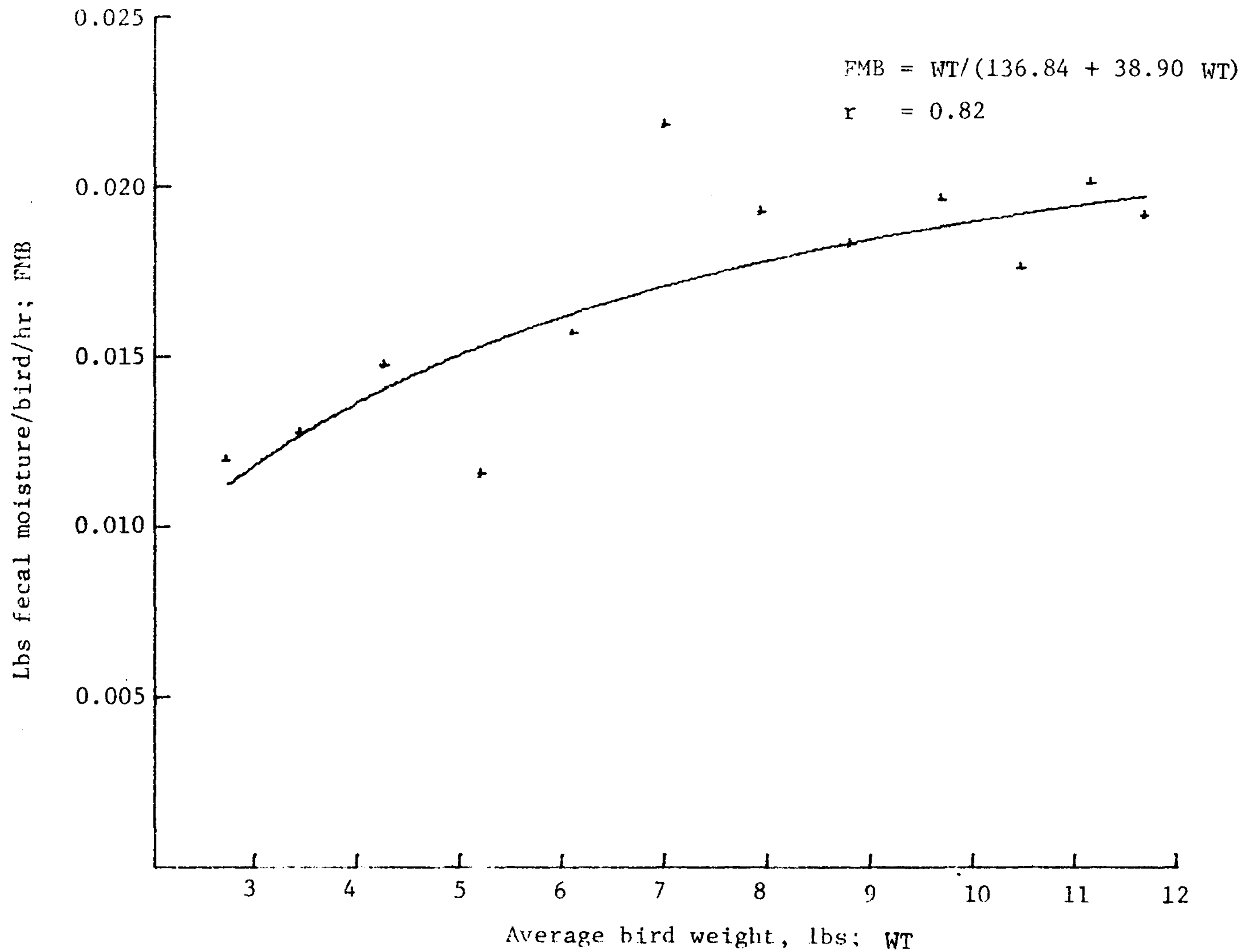

Figure 11. Rate of fecal moisture production per bird versus average bird weight.

Table 1. Rate of feed and water consumption per pound of bird as it was related to age and average bird weight.

Age, weeks	Weight, lbs/bird	Feed consumption lbs	Feed consumption lb/lb bird/hr	Water consumption lbs	Water consumption lb/lb bird/hr
7.3	2.72	13.76	0.00351	24.97	0.00638
8.3	3.43	15.51	0.00313	28.52	0.00573
9.3	4.26	19.13	0.00312	39.74	0.00646
10.3	5.19	20.44	0.00273	30.64	0.00407
11.3	6.10	22.02	0.00251	40.97	0.00466
12.3	7.01	23.87	0.00237	51.72	0.00511
13.3	7.93	24.33	0.00213	54.55	0.00477
14.3	8.80	25.28	0.00199	46.53	0.00367
15.3	9.68	24.52	0.00176	47.81	0.00341
16.3	10.45	25.14	0.00167	43.38	0.00287
17.3	11.14	25.50	0.00159	47.08	0.00292
18.3	11.67	27.31	0.00162	47.23	0.00280

Length of test = 48 hours
Number of birds = 30

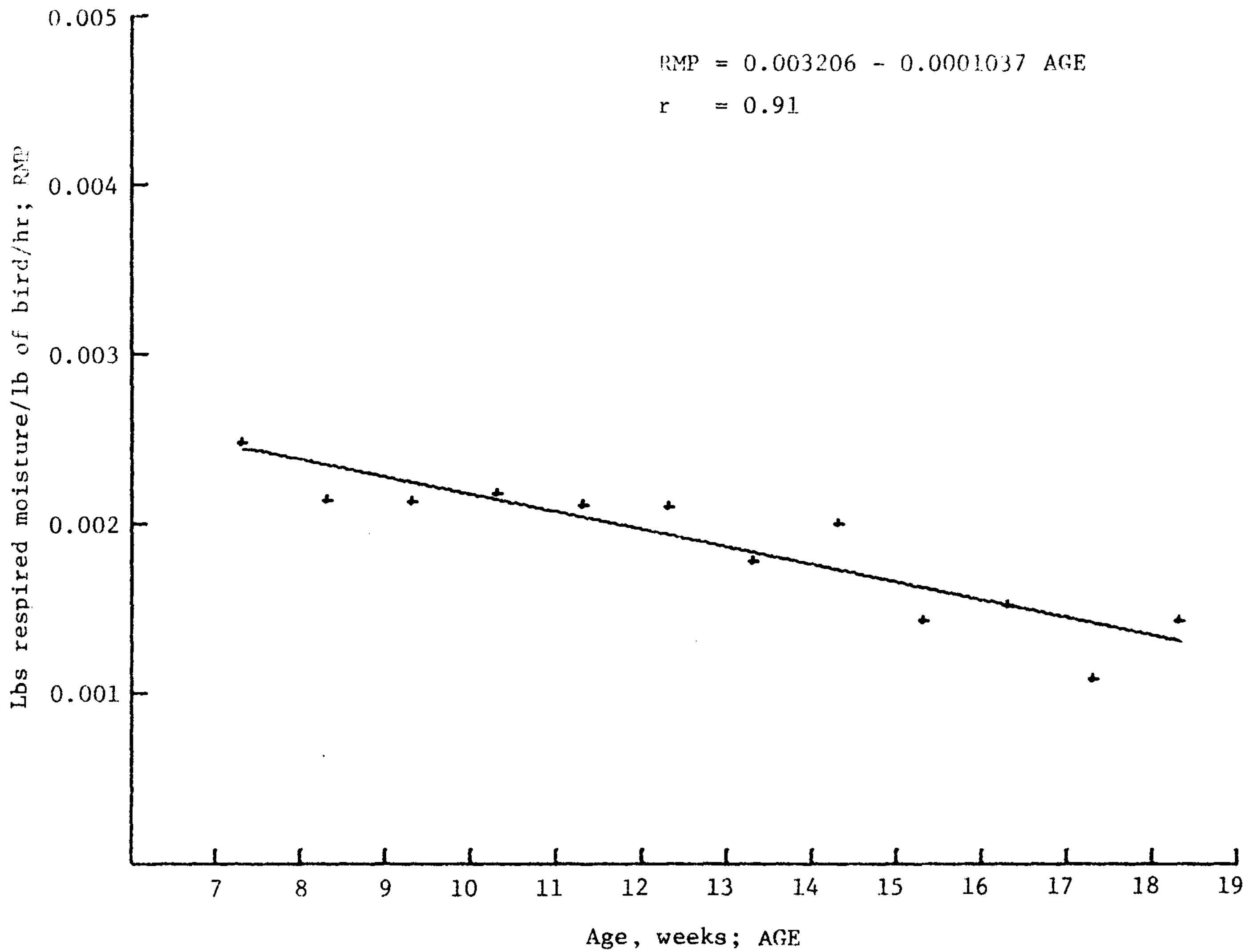

Figure 12. Rate of respired moisture production per pound of bird versus age.

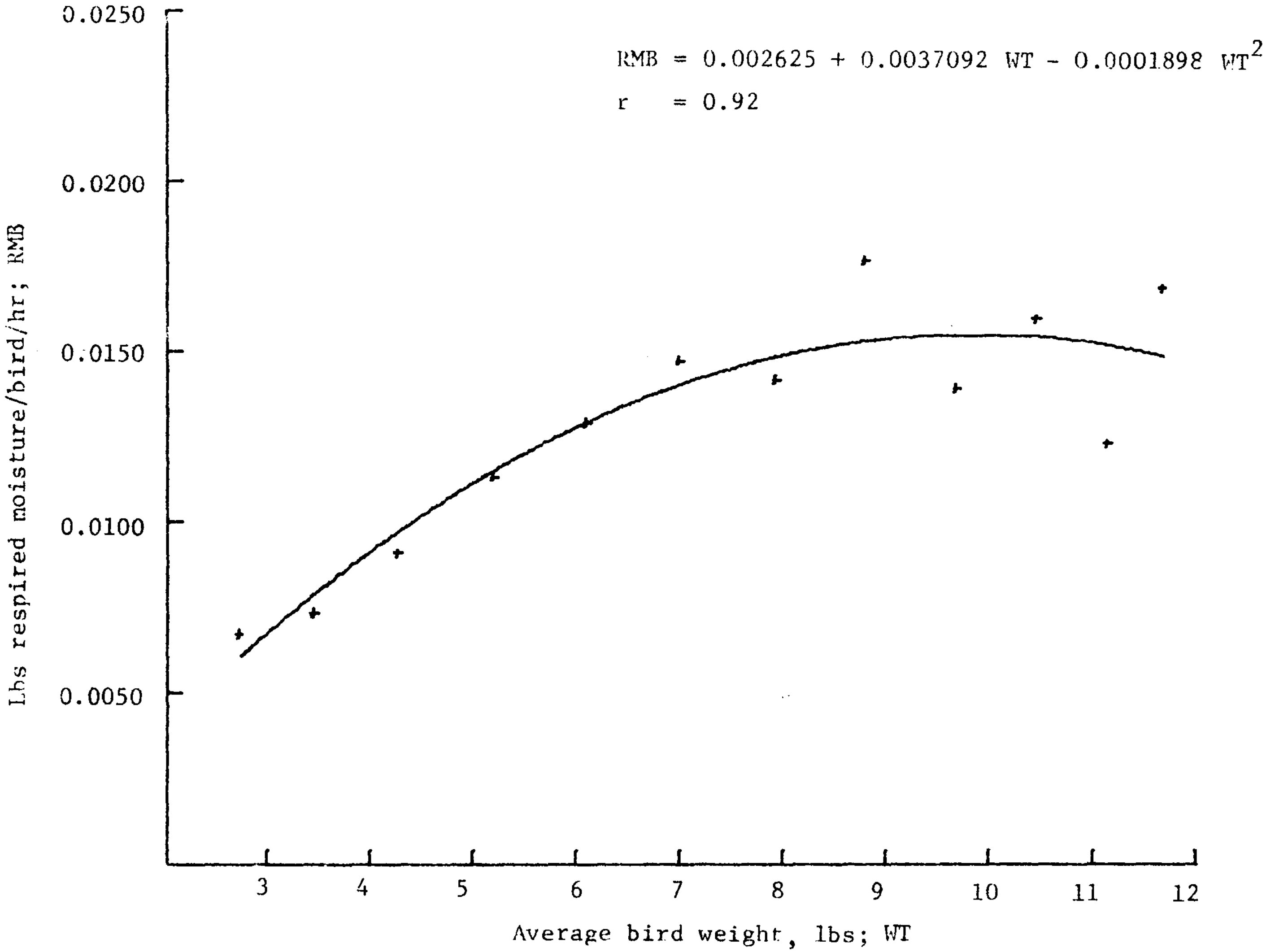

Figure 13. Rate of respired moisture production per bird versus average bird weight.

moisture production per pound of bird versus age and the respired moisture production per bird versus average weight. These figures show the rate of total respired moisture production; Table 2 shows the percent difference between the average daytime and average nighttime respired moisture production.

Discussion of Results

The rate of fecal moisture production per pound of bird declines with age. This trend was expected because the rate of feed and water consumption per pound of bird also declined with age. Toward the end of the growth period, as weight and feed and water consumption appear to asymptote, so does the rate of fecal moisture production per pound of bird. The results obtained by Bingham (2) substantiate the asymptotic relationship shown in Figure 10.

The fecal moisture production rate per bird increases with increasing bird weight. A larger, heavier bird will eliminate more fecal moisture than will a smaller bird. However, as the body weight begins to asymptote near maturity, the rate of fecal moisture production asymptotes in a similar manner.

The respired moisture production rate per pound of bird decreases linearly with age during the grow-out period for medium white female turkeys at 70°F. The trend of these results is very similar to the latent heat production data obtained by Longhouse *et al*. (13) for broilers at 67°F ± 2°F. The similarity of these results with those obtained by Longhouse is explained by the fact that respired moisture production is nothing more than the water equivalent of the latent heat production (5).

The respired moisture production rate per bird increases with increasing bird weight in a manner similar to fecal moisture production shown in Figure 11. Here too, smaller younger birds respire less than do larger birds.

Diurnal Variation of Respired Moisture Production

The rate of respired moisture production during daytime conditions consistently exceeded the rate produced during nighttime conditions by a large margin as shown by Table 2. This is explained by the fact that the turkeys were very active during the light periods while observed activity subsided almost completely during dark periods. These results are in keeping with other investigators (2,5).

Based upon the higher rate of respired moisture production during light periods, environmental controls should be adjusted accordingly to remove excess moisture produced. During dark periods, the controls may be adjusted to remove respired moisture at a slower rate.

Summary of Data

Table 3 presents a summary of data obtained from this investigation. These data are the average that occurred during each 48-hour test period. For example, during test 1 each bird consumed feed at the rate of 0.229 pounds per day.

The ratio of the water consumed to the feed consumed remained fairly constant throughout the investigation. However, the feed

Table 2. Average daytime and average nighttime respired moisture production per pound of bird per hour and the percent that the daytime moisture production exceeded the nighttime production for each test period.

Test	Day	Night	% Difference
1	0.00290	0.00167	+ 73.9
2	0.00237	0.00168	+ 41.0
3	0.00249	0.00144	+ 73.1
4	0.00279	0.00096	+ 190.6
5	0.00256	0.00123	+ 108.6
6	0.00249	0.00134	+ 86.0
7	0.00206	0.00124	+ 66.3
8	0.00224	0.00155	+ 44.1
9	0.00179	0.00074	+ 143.3
10	0.00175	0.00108	+ 62.0
11	0.00142	0.00047	+ 204.4
12	0.00172	0.00090	+ 89.9

Table 3. Summary of data.

Item	Units	Test 1	2	3	4	5	6
Relative hum.	%	58.9	58.1	61.6	59.9	59.6	59.6
Air flow	CFM	26.5	25.4	23.6	31.4	30.2	34.6
Air flow	lbs/min	2.04	1.95	1.82	2.43	2.34	2.68
Age of birds	weeks	7.3	8.3	9.3	10.3	11.3	12.3
Avg wt of bird	lbs	2.72	3.43	4.26	5.19	6.10	7.01
Feed consumption	lbs/day/bird	0.229	0.258	0.319	0.341	0.367	0.398
Water consumption	lbs/day/bird	0.416	0.475	0.662	0.511	0.683	0.862
Water/feed	ratio	1.81	1.84	2.08	1.50	1.86	2.17
Feed conversion	lb feed/lb gain	2.08	2.72	2.36	2.52	2.94	2.95
Fecal production	lb/day/bird	0.360	0.383	0.443	0.350	0.500	0.615
(Water+feed)/feces	ratio	1.79	1.91	2.21	2.43	2.10	2.05
Moisture content feces	%	80.0	80.0	80.0	79.4	75.4	85.2
Fecal mois. prod.	lb/day/bird	0.288	0.307	0.355	0.268	0.377	0.524
Respired moisture	lb/day/bird	0.163	0.177	0.219	0.273	0.310	0.354
Respired/drunk	lbs/lb	0.39	0.37	0.33	0.53	0.45	0.41
Moisture input	lb/day/bird	0.540	0.615	0.836	0.695	0.881	1.079
Moisture output	lb/day/bird	0.523	0.545	0.662	0.639	0.770	0.965
Input-output variation	lb/day/bird	0.017	0.070	0.174	0.056	0.111	0.114
Input-output variation	% diff.	3.3	11.3	20.8	8.1	12.8	10.3

Table 3. Summary of data (Continued).

Item	Units	Test 7	8	9	10	11	12
Relative hum.	%	60.4	64.8	46.4	47.6	42.8	52.1
Air flow	CFM	35.4	21.9	36.1	40.2	35.4	30.4
Air flow	lbs/min	2.74	1.72	2.84	3.17	2.79	2.39
Age of birds	weeks	13.3	14.3	15.3	16.3	17.3	18.3
Avg wt of bird	lbs	7.93	8.80	9.68	10.45	11.14	11.67
Feed consumption	lbs/day/bird	0.405	0.421	0.409	0.419	0.425	0.455
Water consumption	lbs/day/bird	0.909	0.775	0.797	0.723	0.785	0.787
Water/feed	ratio	2.24	1.84	1.95	1.73	1.85	1.73
Feed conversion	lb feed/lb gain	3.12	3.24	3.41	3.35	5.00	6.50
Fecal production	lb/day/bird	0.612	0.583	0.593	0.545	0.613	0.575
(Water+feed)/feces	ratio	2.15	2.05	2.03	2.10	1.97	2.16
Moisture content feces	%	75.6	75.4	79.5	77.7	78.8	80.0
Fecal mois. prod.	lb/day/bird	0.462	0.440	0.472	0.423	0.483	0.460
Respired moisture	lb/day/bird	0.340	0.424	0.334	0.383	0.295	0.405
Respired/drunk	lbs/lb	0.37	0.55	0.42	0.53	0.38	0.51
Moisture input	lb/day/bird	1.129	1.002	1.018	0.948	1.014	1.031
Moisture output	lb/day/bird	0.888	0.948	0.886	0.889	0.835	0.911
Input-output variation	lb/day/bird	0.241	0.054	0.132	0.059	0.179	0.120
Input-output variation	% diff.	21.4	5.4	13.1	6.5	17.8	11.9

conversion ratio approached a very high value of 6.50 pounds of feed consumed per pound of weight gain at the end of the investigation.

Very constant throughout the investigation was the ratio of the feed and water consumed to the fecal material produced. Similarly, the moisture content of the fecal material ranged between 75.4 percent and 85.2 percent.

Analysis of the results showed that the range between moisture input and output was from +3.3 percent to +21.4 percent; no pattern was established, however. The range signified that the measured input exceeded the output in each test. One possible explanation to this fact was that the birds were permitted unlimited access to the feed and water facilities thereby increasing the inherent error due to spillage. Moreover, since no other data were available, Mitchell and Kelley's figure describing the free and metabolized water of the feed (6,10) was used throughout the investigation although this figure may not be constant (11).

CONCLUSIONS

The conclusions which can be drawn from this study are as follows:

1. The air flow metering apparatus functioned satisfactorily. No disturbance whatsoever to the established rate of flow resulted during air flow measurements.
2. Accurate results were yielded by the load cells used for bird weighing. Essentially all bird disturbances during weighing were eliminated.
3. The rate that growing medium white female turkeys produce fecal and respired moisture per pound of bird decreases throughout the grow-out period, at a temperature of 70°F. Fecal moisture production declined logarithmically while respired moisture declined linearly.
4. The rate of fecal and respired moisture produced per bird increases throughout the grow-out period, at 70°F. A nonlinear regression best described the fecal moisture production; respired moisture increased according to a second order regression.
5. The moisture content of the fecal material, wet basis, ranged between 75.4 percent and 85.2 percent at 70°F. The approximation figure of 80 percent moisture as presented in literature appears to be a good approximation.
6. The revised facilities at the Virginia Polytechnic Institute and State University Turkey Research Center worked well in determining the moisture production of growing turkey poults.

RECOMMENDATIONS

In any experimental investigation, replications of the experiment are necessary to allow estimation of the experimental error. Replications, due to the time involved, were not possible in this investigation but are a first order recommendation for further study using growing poults.

The moisture input consistently exceeded the measured output in this investigation. Perhaps some thought needs to be given to devising a method of supplying sufficient quantities of feed and water for proper growth while still attempting to eliminate the error due to spillage. Also, since evidence indicates that the free and metabolizable water of the feed consumed is not constant with age or species, considerable value can be gained from obtaining further data to describe this phenomenon.

Of considerable concern to the author was the method used in collecting the fecal material. Although it was felt that the method was quite adequate, it was further felt that the method was awkward to handle and overly cumbersome to clean. The solution to this problem could be provided by reducing the overall size of the bird cage thereby reducing the size of the pans required to collect the fecal material. Furthermore, with the fecal apparatus smaller, it would enhance the possibility that alternate weighing systems, such as compression load cells or more accurate platform scales, be used.

Recalibration of the strain gage load cells is highly recommended to gain familiarity with their use. This recalibration could either be done in place by applying known weights in the cage or by removing the load cells and recalibrating by means of an Instron testing machine.

Electric hygrometers employing lithium chloride sensing elements have acquired a reputation for erratic performance especially over considerable lengths of time (23). Some erratic performance was noted occasionally with the hygrometer used in this investigation. Thus, the recommendation is made to explore the possibility of alternate methods of humidity measurement, especially if a substantial duration of time will occur.

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APPENDIX I

Flow Nozzle Design

Two preliminary criteria were considered in the selection of a flow meter to measure air flow. These were:

1. Remote readings were necessary in order to eliminate disturbing the air flow to the birds.
2. The flow meter and related equipment were restricted in size by the width of the plenum chamber.

Based on these criteria, any one of the three primary devices* could have been chosen. Consultations with Dr. H. L. Wood of the Mechanical Engineering Department, Virginia Polytechnic Institute and State University, revealed that a flow nozzle produces good results and can be purchased at low cost. Thus a flow nozzle was selected.

The flow nozzle was designed on the basis of a readable pressure drop, assuming the lowest expected air flow rate to occur. A 2.50 inch (throat diameter) nozzle provided adequate readability when attached to a 4.75 inch diameter pipe, according to the flow equation for nozzles presented in detail by ASME (19).

The use of a flow nozzle required that a steady flow exist in order to measure pressure differential. The piping requirements were determined from Schedule 2, Figure 3, Flow Meter Engineering Handbook (24) and further consultations with Dr. Wood. Honeycomb-type straightening vanes were constructed and placed into the piping preceding the nozzle. Since the air temperature in the plenum chamber was below

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*The basic primary devices are the Venturi tube, the flow nozzle, and the thin-plate concentric orifice (19).

that of the air passing through the nozzle, insulation of the nozzle piping, as required by guidelines established by ASME (19), was a necessary precaution.

Determination of Discharge Coefficient

The discharge coefficient, C (refer to equation #107, Fluid Meters-Their Theory and Application) (19), needed to be known to determine the actual rate of flow through the nozzle. Through the aid of a computer program, this coefficient was determined for each range of flow rates expected to be encountered. In short, this involved determining the Reynolds number for an assumed rate of flow and referring to Figure 93 of Fluid Meters-Their Theory and Application (19) to determine C.

Flow Rate Tabulation

The differential pressure across the flow nozzle was the only pertinent quantity needed prior to determining the actual flow rate. This, as previously mentioned, was measured using an inclined tube differential manometer. Table 4 is a calibration table established for the nozzle as an aid in determining the actual flow rate when the differential pressure drop was known.

Table 4. Calibration table for the 2.50 inch nozzle used to measure air flow.

Pressure drop as read on manometer, inches	Air flow rate, CFM
0.000	0.0
0.010	10.9
0.020	15.4
0.030	18.9
0.040	21.9
0.050	24.7
0.060	27.0
0.070	29.2
0.080	31.2
0.090	33.1
0.100	35.0
0.110	36.7
0.120	38.5
0.130	40.0
0.140	41.6
0.150	43.0
0.160	44.4
0.170	45.8
0.180	47.1
0.190	48.4
0.200	49.7
0.210	50.9
0.220	52.1
0.230	53.3
0.240	54.4
0.250	55.5
0.260	56.6
0.270	57.7
0.280	58.8
0.290	59.8
0.300	60.8

Design of Strain Gage Load Cells

Two primary considerations were involved in designing the strain gage load cells. First, a maximum total weight was estimated as 1000 pounds, or 250 pounds per load cell, from the estimated cage weight and expected bird weight. Secondly, a sensitivity of approximately 10 microinches of strain for each pound of weight increase per load cell was essential for each load cell. This allowed a sensitivity of approximately 2.5 microinches of strain, per load cell, for a total bird weight increase of one pound. Since 2.5 microinches of strain was readable on the strain indicator, this allowed determining the total bird weight with an accuracy close to one pound.

Several different elastic materials, each with a different modulus of elasticity E, were considered. Aluminum was the most suitable material to satisy the above sensitivity requirements. In addition, the maximum expected load did not surpass the yield stress of the designed section. The dimensions of the designed section were 0.240 x 0.125 inches, thus giving a cross sectional area of 0.0300 square inches. The stress developed in this section at a load of 250 pounds is 8350 pounds per square inch, which is less than the yield stress of aluminum.

For sensitivity of the designed section, the strain at a load of 100 pounds, for example, was determined from Hooke's Law. Then the strain at a load of 101 pounds was determined. This gave a strain sensitivity of approximately 4 microinches per pound of increased load. By using strain gages with a gage factor of 2.1, this sensitivity was increased to approximately 8.5 microinches per pound of increased load. Based on these preliminary design calculations, a sample load cell was constructed and wired; it exhibited a sensitivity of over 10 microinches per pound of increased load. As this was more than satisfactory, the remaining load cells were fabricated, wired, and mounted onto the bird cage.

Since the load cells were to be exposed to possible contaminating conditions and fluctuating humidities, waterproofing of some sort was essential to maintain their stability. This waterproofing was done with Silicone Seal, a common silicone-based bathtub sealer manufactured by the General Electric Corporation. This material provided excellent adherence, electrical insulation, and durability.

APPENDIX II

Data Acquisition Schedule

Day	Time	Occurrence+
Thursday	8:00 p.m.*	Birds weighed.
Friday	3:45 p.m.	Test period began.
		Fecal collection pans weighed.
		Fecal sample pan prepared, weighed, and placed in bird chamber.
		Feed pans weighed.
		Water pan weighed.
		Differential manometer read.
		Recording potentiometer turned on.
		Bird chamber doors sealed.
	4:00 p.m.	Dark period for birds began.
	6:00 p.m.	Humidity readings for first dark period began (one reading taken approximately every 45 minutes). Differential manometer was read every 45 minutes.
	12:00 p.m.	Humidity readings ended.
		Light period for birds began
Saturday	7:00 a.m.	Humidity readings for first light period began. Differential manometer read.
	9:00 a.m.	Feed pans weighed and refilled.
		Water consumption measured.
	11:00 a.m.	Humidity readings continued.
	4:00 p.m.	Humidity readings for first light period ended.

+all pertinent data recorded.

*lights were off from 4 p.m. to midnight each day.

Data Acquisition Schedule (Continued).

Day	Time	Occurrence
		Light period ended, dark period began.
	6:00 p.m.	Humidity readings for second dark period initiated. Differential manometer readings taken.
	12:00 p.m.	Humidity readings for second dark period ended.
		Bird light period began.
Sunday	7:00 p.m.	Humidity readings for second dark period began.
		Differential manometer read.
	9:00 a.m.	Feed pans weighed and refilled.
		Water consumption measured.
	11:00 a.m.	Humidity readings continued.
	3:45 p.m.	Humidity readings for second light period ended.
		Bird chamber opened.
		Feed pans weighed.
		Water consumption measured.
		Fecal sample pan removed and weighed.
		Fecal collection pans weighed.
	4:00 p.m.	Test period ended.
		Dark period began.
		Fecal sample drying procedure began.
	8:00 p.m.	Birds weighed.

APPENDIX III

Calibration of Test Equipment

Hygrometer

The hygrometer used in this investigation was an electric hygrometer employing lithium chloride sensing elements. Several checks were necessary to ascertain that this instrument was operating within the manufacturers tolerance limits. At first, no checks performed on the instrument were valid. Sensing elements were returned to the manufacturer and confirmed to be beyond calibration tolerances. New elements were purchased; all subsequent checks for calibration gave satisfactory results when compared with wet and dry bulb temperature readings taken simultaneously with the instrument reading. The overall sentiment regarding the use of the hygrometer was that it operated satisfactorily but required frequent calibration checks.

Multipoint Recording Potentiometer

The accuracy of the recording potentiometer was of utmost importance throughout this investigation. For this reason, calibration checks at several different temperatures were made by checking recorded temperatures against several standard mercury-in-glass laboratory thermometers.

Each of the eleven thermocouples used in this investigation was checked against the known temperature of 32°F for an ice-bath mixture. Secondly, each thermocouple was checked against thermometer readings of the surrounding air. In every case, the thermocouples recorded precisely the same temperature as observed on the laboratory thermometers.

Flow Nozzle

Although every ASME recommendation was followed to the point in construction of the flow nozzle, some method of corroborating the air flow rate computed from the flow equation was necessary. This corroboration was accomplished by using a hot wire anemometer and traversing the outlet end of the flow nozzle to determine the average velocity of the air flowing. This average velocity multiplied by the cross sectional area of the nozzle throat gave the air flow rate. Calibration checks performed as described revealed that the flow rates computed by both methods were in agreement within 2%.

Fecal Material Apparatus

The two platform scales used to weigh the collected fecal material were checked individually for accuracy by applying a known weight and observing the weight recorded by the scales. Furthermore, while the scales were in use, checks for accuracy were initiated by applying a known weight and observing the weight increase as given by both scales. In all cases of checking, the weight indicated by the platform scales agreed within 5% of the known weight.

Checks initiated for evaporation from the fecal pans were done in two ways. First, with no birds in the cage, humidity readings of the incoming and exit air were observed and the specific humidity of each was determined. In a 24-hour period, the specific humidity of the entrance and exit air were identical. Secondly, the weight of the pans was determined by reading the platform scales. Seven days later, a second reading was taken and this reading was in exact agreement with the first reading. These two checks served as ample evidence that there was no measurable moisture loss from the fecal pans.

Strain Gage Load Cells

The original calibration of the strain gage load cells was performed on an Instron testing machine. The Instron machine, itself, was calibrated with precisely known weights, but further calibration checks were performed on the load cells to confirm accuracy. These checks were accomplished by determining the bird weight by use of the load cells, then entering the bird chamber, removing all birds and weighing them on a separate set of scales. This procedure was done twice during the investigation and the results of each weighing were within 1% of the weight determined by using the load cells.

Saturation Checks

The ability of the saturater and plenum chamber to fully saturate the air was of prime concern. Wet and dry bulb temperature measurements were taken frequently and, as they were identical, saturation was confirmed. As a further check for saturation, the electric hygrometer, with an appropriate sensing element to measure high relative humidity, was inserted into the entrance duct; this reaffirmed that the inlet air was fully saturated by the time that it entered the bird chamber.

Evaporation from Fountain

No appreciable evaporation from the birds drinking water source occurred. This was proved by weighing a separate fountain, inaccessible to the birds, over a period of time. In relation to the amount of moisture respired, the evaporated water from the fountain was insignificant.

APPENDIX IV

Test No. 1: 3:45 p.m., Oct. 15, 1971, to 3:45 p.m. Oct. 17, 1971.

Test Data

weight of feed consumed	= 13.76 lbs
weight of water consumed	= 24.97 lbs
total bird weight before test	= 78.20 lbs
total bird weight after test	= 84.90 lbs
bird weight increase during test	= 6.70 lbs
average bird weight	= 2.72 lbs
fecal sampling pan prior to test	= 12147 gm
fecal sampling pan at end of test	= 13120 gm
weight of dry fecal material in sample (data missing)*	
weight of fecal material accumulated in collection pans	= 21.6 lbs
average manometer reading	= 0.058 in
air flow rate, CFM	= 26.5 CFM
average temperature of inlet air	= 51.5°F
average temperature of exit air	= 70.7°F
average relative humidity of exit air	= 58.9%
average Δ specific humidity, light periods	= 0.00195
average Δ specific humidity, dark periods	= 0.00112

Moisture Production

fecal moisture production = 0.00441 (rate per pound of bird)
= 0.01200 (rate per bird)

moisture respired during light periods	= 7.58 lbs
moisture respired during dark periods	= 1.18 lbs

respired moisture production = 0.00249 (rate per pound of bird)
= 0.00678 (rate per bird)

Moisture Balance

input moisture	= 32.40 lbs
output moisture	= 31.33 lbs
% difference	= +3.3

*The fecal moisture content for tests with missing data was assumed as 80 percent.

Test No. 2: 3:45 p.m., Oct. 22, 1971, to 3:45 p.m., Oct. 24, 1971.

Test Data

weight of feed consumed	= 15.51 lbs
weight of water consumed	= 28.52 lbs
total bird weight before test	= 100.00 lbs
total bird weight after test	- 106.90 lbs
bird weight increase during test	= 6.90 lbs
average bird weight	= 3.43 lbs
fecal sampling pan prior to test (data missing)	
fecal sampling pan at end of test (data missing)	
weight of dry fecal material in sample (data missing)	
weight of fecal material accumulated in collection pans	= 23.00 lbs
average manometer reading	= 0.053 in.
air flow rate, CFM	= 25.4 CFM
average temperature of inlet air	= 49.8°F
average temperature of exit air	= 71.0°F
average relative humidity of exit air	= 58.1%
average Δ specific humidity, light periods	= 0.00213
average Δ specific humidity, dark periods	= 0.00151

Moisture Production

fecal moisture production = 0.00372 (rate per pound of bird)
= 0.01278 (rate per bird)

moisture respired during light periods	= 7.84 lbs
moisture respired during dark periods	= 2.78 lbs

respired moisture production = 0.00215 (rate per pound of bird)
= 0.00737 (rate per bird)

Moisture Balance

Input moisture	= 36.90 lbs
Output moisture	= 32.72 lbs
% difference	= +11.3

Test No. 3: 3:45 p.m., Oct. 29, 1971, to 3:45 p.m., Oct. 31, 1972.

Test Data

weight of feed consumed	= 19.13 lbs
weight of water consumed	= 39.74 lbs
total bird weight before test	= 123.90 lbs
total bird weight after test	= 132.00 lbs
bird weight increase during test	= 8.10 lbs
average bird weight	= 4.26 lbs
fecal sampling pan prior to test	= 10477 gm
fecal sampling pan at end of test	= 10985 gm
weight of dry fecal material in sample	= 102.0 gm
weight of fecal material accumulated in collection pans	= 26.6 lbs
average manometer reading	= 0.046 in.
air flow rate, CFM	= 23.6 CFM
average temperature of inlet air	= 49.5°F
average temperature of exit air	= 70.7°F
average relative humidity of exit air	= 61.6%
average Δ specific humidity, light periods	= 0.00292
average Δ specific humidity, dark periods	= 0.00169

Moisture Production

fecal moisture production = 0.00346 (rate per pound of bird)
= 0.01478 (rate per bird)

moisture respired during light periods = 10.18 lbs

moisture respired during dark periods = 2.94 lbs

respired moisture production = 0.00214 (rate per pound of bird
= 0.00911 (rate per bird)

Moisture Balance

input moisture	= 50.07 lbs
output moisture	= 39.66 lbs
% difference	= +20.8

Test No. 4: 3:45 p.m., Nov. 5, 1971, to 3:45 p.m., Nov. 7, 1971.

Test Data

weight of feed consumed	= 20.44 lbs
weight of water consumed	= 30.64 lbs
total bird weight before test	= 152.00 lbs
total bird weight after test	= 160.00 lbs
bird weight increase during test	= 8.00 lbs
average bird weight	= 5.19 lbs
fecal sampling pan prior to test	= 12739 gm
fecal sampling pan at end of test	= 13649 gm
weight of dry fecal material in sample	= 181.7 gm
weight of fecal material accumulated in collection pans	= 21.00 lbs
average manometer reading	= 0.081 in.
air flow rate, CFM	= 31.4 CFM
average temperature of inlet air	= 48.5°F
average temperature of exit air	= 70.9°F
average relative humidity of exit air	= 59.9%
average Δ specific humidity, light periods	= 0.00299
average Δ specific humidity, dark periods	= 0.00103

Moisture Production

fecal moisture production = 0.00223 (rate per pound of bird)
= 0.01158 (rate per bird)

moisture respired during light periods = 13.95 lbs

moisture respired during dark periods = 2.40 lbs

respired moisture production = 0.00219 (rate per pound of bird)
= 0.01135 (rate per bird)

Moisture Balance

input moisture	= 41.68 lbs
output moisture	= 38.29 lbs
% difference	= +8.1

Test No. 5: 3:45 p.m., Nov. 12, 1971, to 3:45 p.m., Nov. 14, 1971

Test Data

weight of feed consumed	= 22.02 lbs
weight of water consumed	= 40.97 lbs
total bird weight before test	= 179.20 lbs
total bird weight after test	= 186.70 lbs
bird weight increase during test	= 7.50 lbs
average bird weight	= 6.10 lbs
fecal sampling pan prior to test	= 2989 gm
fecal sampling pan at end of test	= 3446 gm
weight of dry fecal material in sample	= 112.1 gm
weight of fecal material accumulated in collection pans	= 30.00 lbs
average manometer reading	= 0.075 in.
air flow rate, CFM	= 30.2 CFM
average temperature of inlet air	= 48.0°F
average temperature of ixit air	= 70.7°F
average relative humidity of exit air	= 59.6%
average Δ specific humidity, light periods	= 0.00334
average Δ specific humidity, dark periods	= 0.00160

Moisture Production

fecal moisture production = 0.00258 (rate per pound of bird)
= 0.01571 (rate per bird)

moisture respired during light periods = 15.02 lbs

moisture respired during dark periods = 3.60 lbs

respired moisture production = 0.00212 (rate per pound of bird)
= 0.01293 (rate per bird)

Moisture Balance

input moisture	= 52.86 lbs
output moisture	= 46.11 lbs
% difference	= +12.8

Test No. 6: 3:45 p.m., Nov. 19, 1971, to 3:45 p.m., Nov. 21, 1971.

Test Data

weight of feed consumed	= 23.87 lbs
weight of water consumed	= 51.72 lbs
total bird weight before test	= 206.50 lbs
total bird weight after test	= 214.00 lbs
bird weight increase during test	= 7.50 lbs
average bird weight	= 7.01 lbs
fecal sampling pan prior to test	= 4099 gm
fecal sampling pan at end of test	= 4720 gm
weight of dry fecal material in sample	= 91.5 gm
weight of fecal material accumulated in collection pans	= 36.90 lbs
average manometer reading	= 0.098 in
air flow rate, CFM	= 34.6 CFM
average temperature of inlet air	= 48.8°F
average temperature of exit air	= 71.0°F
average relative humidity of exit air	= 59.6%
average Δ specific humidity, light periods	= 0.00325
average Δ specific humidity, dark periods	= 0.00175

Moisture Production

fecal moisture production = 0.00312 (rate per pound of bird)
= 0.02183 (rate per bird)

moisture respired during light periods = 16.74 lbs

moisture respired during dark periods = 4.50 lbs

respired moisture production = 0.00211 (rate per pound of bird)
= 0.01475 (rate per bird)

Moisture Balance

input moisture	= 64.61 lbs
output moisture	= 57.94 lbs
% difference	= +10.3

Test No. 7: 3:45 p.m., Nov. 26, 1971, to 3:45 p.m., Nov. 28, 1971.

Test Data

weight of feed consumed	= 24.33 lbs
weight of water consumed	= 54.55 lbs
total bird weight before test	= 234.00 lbs
total bird weight after test	= 242.00 lbs
bird weight increase during test	= 8.00 lbs
average bird weight	= 7.93 lbs
fecal sampling pan prior to test	= 5204 gm
fecal sampling pan at end of test	= 5943 gm
weight of dry fecal material in sample	= 187.5 gm
weight of fecal material accumulated in collection pans	= 36.70 lbs
average manometer reading	= 0.102 in.
air flow rate, CFM	= 35.4 CFM
average temperature of inlet air	= 47.7°F
average temperature of exit air	= 70.0°F
average relative humidity of exit air	= 60.4%
average Δ specific humidity, light periods	= 0.00298
average Δ specific humidity, dark periods	= 0.00179

Moisture Production

fecal moisture production = 0.00243 (rate per pound of bird)
= 0.01927 (rate per bird)

moisture respired during light periods = 15.70 lbs

moisture respired during dark periods = 4.72 lbs

respired moisture production = 0.00179 (rate per pound
= 0.01418 (rate per bird)

Moisture Balance

input moisture	= 67.69lbs
output moisture	= 53.24 lbs
% difference	= +21.4

Test No. 8: 3:45 p.m., Dec. 3, 1971, to 3:45 p.m., Dec. 5, 1971.

Test Data

weight of feed consumed	= 25.28 lbs
weight of water consumed	= 46.53 lbs
total bird weight before test	= 260.00 lbs
total bird weight after test	= 268.00 lbs
bird weight increase during test	= 8.00 lbs
average bird weight	= 8.80 lbs
fecal sampling pan prior to test	= 5210 gm
fecal sampling pan at end of test	= 5733 gm
weight of dry fecal material in sample	= 129.1 gm
weight of fecal material accumulated in collection pans	= 35.00 lbs
average manometer reading	= 0.040 in.
air flow rate, CFM	= 21.9 CFM
average temperature of inlet air	= 41.6°F
average temperature of exit air	= 70.6°F
average relative humidity of exit air	= 64.8%
average Δ specific humidity, light periods	= 0.00571
average Δ specific humidity, dark periods	= 0.00396

Moisture Production

fecal moisture production = 0.00208 (rate per pound of bird)
= 0.01833 (rate per bird)

moisture respired during light periods = 18.90 lbs

moisture respired during dark periods = 6.56 lbs

respired moisture production = 0.00201 (rate per pound of bird
= 0.01768 (rate per bird)

Moisture Balance

input moisture	= 60.18 lbs
output moisture	= 56.92 lbs
% difference	= +5.4

Test No. 9: 3:45 p.m., Dec. 10, 1971, to 3:45 p.m., Dec. 12, 1971.

Test Data

weight of feed consumed	= 24.52 lbs
weight of water consumed	= 47.81 lbs
total bird weight before test	= 287.00 lbs
total bird weight after test	= 294.00 lbs
bird weight increase during test	= 7.00 lbs
average bird weight	= 9.68 lbs
fecal sampling pan prior to test	= 5170 gm
fecal sampling pan at end of test	= 5910 gm
weight of dry fecal material in sample	= 152.0 gm
weight of fecal material accumulated in collection pans	= 35.60 lbs
average manometer reading	= 0.106 in.
air flow rate, CFM	= 36.1 CFM
average temperature of inlet air	= 39.3°F
average temperature of exit air	= 70.6°F
average relative humidity of exit air	= 46.4%
average Δ specific humidity, light periods	= 0.00305
average Δ specific humidity, dark periods	= 0.00125

Moisture Production

fecal moisture production = 0.00203 (rate per pound of bird)
= 0.01965 (rate per bird)

moisture respired during light periods = 16.64 lbs

moisture respired during dark periods = 3.42 lbs

respired moisture production = 0.00144 (rate per pound of bird)
= 0.01393 (rate per bird)

Moisture Balance

input moisture	= 61.05 lbs
output moisture	= 53.04 lbs
% difference	= +13.1

Test No. 10: 3:45 p.m., Dec. 17, 1971, to 3:45 p.m., Dec. 19, 1971.

Test Data

weight of feed consumed	= 25.14 lbs
weight of water consumed	= 43.38 lbs
total bird weight before test	= 310.00 lbs
total bird weight after test	= 317.00 lbs
bird weight increase during test	= 7.00 lbs
average bird weight	= 10.45 lbs
fecal sampling pan prior to test	= 5496 gm
fecal sampling pan at end of test	= 6274 gm
weight of dry fecal material in sample	= 173.4 gm
weight of fecal material accumulated in collection pans	= 32.70 lbs
average manometer reading	= 0.131 in.
air flow rate, CFM	= 40.2 CFM
average temperature of inlet air	= 39.4°F
average temperature of exit air	= 70.8°F
average relative humidity of exit air	= 47.6%
average Δ specific humidity, light periods	= 0.00288
average Δ specific humidity, dark periods	= 0.00178

Moisture Production

fecal moisture production = 0.00169 (rate per pound of bird)
= 0.01764 (rate per bird)

moisture respired during light periods = 17.56 lbs

moisture respired during dark periods = 5.42 lbs

respired moisture production = 0.00153 (rate per pound of bird)
= 0.01596 (rate per bird)

Moisture Balance

input moisture	= 56.86 lbs
output moisture	= 53.26 lbs
% difference	= +6.5

Test No. 11: 3:45 p.m., Dec. 24, 1971, to 3:45 p.m., Dec. 26, 1971.

Test Data

weight of feed consumed	= 25.50 lbs
weight of water consumed	= 47.08 lbs
total bird weight before test	= 331.50 lbs
total bird weight after test	= 337.00 lbs
bird weight increase during test	= 5.50 lbs
average bird weight	= 11.14 lbs
fecal sampling pan prior to test	= 5742 gm
fecal sampling pan at end of test	= 6354 gm
weight of dry fecal material in sample	= 129.6 gm
weight of fecal material accumulated in collection pan	= 36.80 lbs
average manometer reading	= 0.102 in.
air flow rate, CFM	= 35.4 CFM
average temperature of inlet air	= 38.4°F
average temperature of exit air	= 70.4°F
average relative humidity of exit air	= 42.8%
average Δ specific humidity, light periods	= 0.00287
average Δ specific humidity, dark periods	= 0.00091

Moisture Production

fecal moisture production = 0.00181 (rate per pound of bird)
= 0.02014 (rate per bird)

moisture respired during light periods	= 15.02 lbs
moisture respired during dark periods	= 2.71 lbs

respired moisture production = 0.00110 (rate per pound of bird)
= 0.01231 (rate per bird)

Moisture Balance

input moisture	= 60.85 lbs
output moisture	= 50.05 lbs
% difference	= +17.8

Test No. 12: 3:45 p.m., Dec. 31, 1971, to 3:45 p.m., Jan. 2, 1972.

Test Data

weight of feed consumed	= 27.31 lbs
weight of water consumed	= 47.23 lbs
total bird weight before test	= 348.00 lbs
total bird weight after test	= 352.50 lbs
bird weight increase during test	= 4.50 lbs
average bird weight	= 11.67 lbs
fecal sampling pan prior to test (data missing)	
fecal sampling pan at end of test (data missing)	
weight of dry fecal material in sample (data missing)	
weight of fecal material accumulated in collection pans	= 34.50 lbs
average manometer reading	= 0.076 in.
air flow rate, CFM	= 30.4 CFM
average temperature of inlet air	= 38.7°F
average temperature of exit air	= 70.3°F
average relative humidity of exit air	= 52.1%
average Δ specific humidity, light periods	= 0.00416
average Δ specific humidity, dark periods	= 0.00218

Moisture Production

fecal moisture production = 0.00164 (rate per pound of bird)
= 0.01917 (rate per bird)

moisture respired during light periods = 19.15 lbs

moisture respired during dark periods = 5.03 lbs

respired moisture production = 0.00144 (rate per pound of bird)
= 0.01686 (rate per bird)

Moisture Balance

input moisture	= 61.98 lbs
output moisture	= 54.61 lbs
% difference	= +11.9

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MOISTURE PRODUCTION OF GROWING TURKEY POULTS

by

Kurt Bachman

(ABSTRACT)

Increased confinement housing of turkeys has created a need for data on the moisture production of turkeys. Sufficient data do not exist in the literature.

Some research has been conducted at the Virginia Polytechnic Institute and State University Turkey Research Center, but the past facilities dealt only with full grown turkeys. Some modifications of these facilities were necessary in order to adapt them to growing turkey poults. These modifications were made and the moisture production of one group of medium white female turkey poults was determined during the grow-out period. The environmental temperature was kept constant at 70°F $\pm$ 1°F; relative humidity ranged from 42.8 percent to 64.8 percent.

A brief summary of the results obtained from the moisture production study are as follows:

1. The rate of fecal moisture production per pound of bird declined with age during the grow-out period. A logarithmic function was found to best describe this relationship.
2. The rate of fecal moisture production per bird increased with weight during the grow-out period; an equation was found which satisfactorily described this.
3. The rate of respired moisture production per pound of bird decreased linearly with age.

4. The rate of respired moisture production per bird increased with weight during the grow-out period. A second degree polynomial best described this relationship.
5. A moisture input and output balance was used to help check accuracy. Input measurements were consistently greater than the output; this range was from 3.3 percent to 21.4 percent.