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Effects of Environmental Temperature on Egg Production, Food Intake and Water Consumption in Laying White Leghorns

III. Effects of Humidity

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(Figs. 1-5; Table 1)

The humidity in the air expressed as relative humidity (RH) and calculated from the difference between dry bulb temperature (DBT) and wet bulb temperature (WBT), affected also by the air movement in accordance, has a causal relation with the dissipation of heat produced by animals.

Although under high humidity especially in higher temperature ranges an increase in the respiration rates and a rise of rectal temperatures with a decrease in milk production were reported by several researchers on domestic cattle, few reports concerned themselves with the effects of humidity on laying hens. MIMURA *et al.* (1968)[1] reported an increase of respiration rates under conditions higher than 31°C of DBT. The proportionate increase of rates under high WBT conditions was verified in White Leghorns and crossbreds (WC×RIR). The examinations showed that although the increase of respiration rates per 1°C elevation of WBT was 7-12/min., while the same rates per 1°C elevation of DBT were 20-28/min. They reported furthermore that a rise of rectal temperature was also affected by higher WBT conditions. Yet DBT proved to be more effective than WBT. It has been observed by many researchers that the quality of the egg shells tends to be much poorer in summer than in the other seasons. Moreover WARREN and SCHNEPEL (1940)[2] reported that high humidity tends to accentuate the depressing effects of high temperature on the shell thickness.

The effects of humidity may be conjectured to be minor than DBT as was reported by SIEGEL (1963)[3]. However, as the number of laying hens fed in one windowless installation increases, the ventilation for the outlet of moist air and the environmental temperature control become more and more important problems.

In a previous paper (1970)[4], we have already reported that the effects of dry bulb temperature elevation induce a decrease of food intake and an increase of water consumption. In subsequent paper (1971)[5], we reported the same effects in the case of corn oil supplemented feeding. We performed both these studies under the account to dry bulb temperature conditions as environmental temperature. Although WBT varies according to the air velocity, to radiation etc., yet under a constant air

velocity and negresible radiation in a temperature room, the change of WBT at the same DBT may well represent the change in humidity.

The present study was made with the purpose of deterniming the effects of humidity, under several DBT; the change of WBT on food intake, water consumption and egg shell quality in White Leghorns under several different experiments.

MATERIALS AND METHODS

Main data were obtained from 24 mature White Leghorn hens. These had been selected from the flocks hatched at the Fukuyama Poultry Center, on the 5th of February, 1970, and had been reared in this laboratory. They were laying at a rate more than 70% under natural environment, using the commercial standard diet during the last 37 days.

Every 14 or 21 days test was conducted in Experiment I from July 31 to October 31, 1970, under room temperatures of 30 and 32.5°C with 60 and/or 80 % of RH, and also with the same flocks in Experiment II from April 27, 1971 to July 20, 1971 under room temperatures of 25, 30, 32.5°C with 40 to 60% of RH.

And supplementarily the other data from 10 birds under a lower humidity in the 1970 Experiment (A), previously reported, and from the same birds and under a higher humidity in the 1970 Experiment (B) (unpublished), which was performed from July 8, 1969 to August 21, 1969 under temperatures of 30 and 32.5°C with 60 to 70% of RH. In the same way the other data from 8 birds in the 1971 Experiment previously reported, were compared to the present data.

In Exp. I, the results of the first week were excluded from the data as being a preliminary period of the test for the acclimation from the natural environment to the controlled one. Experimental periods and set environmental temperatures are shown in Table 1.

The supplying of food and water, weighing the eggs and measurements of the food intake and water consumption were done at 13:00 every day in the same way as reported in the previous papers.

The artificial lighting was done during 13 hours every day from 6:00 in the morning to 7:00 in the evening with 2 electric bulbs of 60 W.

After the weighing of the eggs, in Exp. I and II, each egg was broken off, egg white residuals were washed out and the shells with their menbranes were dried during 24 hours at 55°C in an electric oven. After cooling off the room temperature, the weighing of the egg shells was done with a balance and thickness of the egg shell was measured with a dial pipe gauge of 0.01 g or mm preciceness. The thickness was measured near both ends and at the two middle portions. The average of these four measurements was assumed as shell thickness of each egg. The egg shell measurements were calculated from the last three days of each week.

In each experiment relative humidities were controlled between ±10% and

Table 1. Set temperature, food intake, water consumption and shell quality in each experiment.

Exp.	Set temperature °C	Date from to	Mean measured DBT °C	WBT °C	RH %	Food intake g/kg	Water consump. g/kg	Water/food ratio	Egg weight g	g/kg	Egg shell weight/egg/kg g	%	Shell thickness mm	Body weight kg	Hatching day of hens	Remarks hen numbers used
		1970														
	32.5	Aug. 8—Aug.29	32.2	26.9	59	49	185	3.75	49.8	32.9	4.76	14.5	0.368	1.52		
I	30	Aug. 30—Sept.19	29.9	24.9	60	55	165	3.02	51.9	34.2	5.11	15.2	0.368	1.52	Feb. 5,	24
	30	Sept. 20—Oct. 10	30.0	27.5	79	55	163	2.97	54.6	34.8	5.23	15.1	0.368	1.57	1970	
	32.5	Oct. 11—Oct. 31	32.3	29.6	78	50	198	3.97	53.6	35.5	5.16	14.6	0.368	1.50		
		1971														
	25	Apr. 27—May 11	25.0	18.3	45	62	138	2.24	63.1	32.5	5.98	18.4	0.383	1.94		
	30	May 12—Jun. 1	29.6	21.7	43	56	154	2.74	60.1	32.1	5.71	17.6	0.379	1.88	Feb. 5,	24
II	32.5	Jun. 2—Jun. 22	32.3	24.3	45	51	154	2.88	57.8	32.3	5.46	17.0	0.372	1.79	1970	
	30	Jun. 23—Jul. 6	29.3	24.0	56	57	144	2.54	58.1	32.7	5.73	17.6	0.387	1.77		
	25	Jul. 7—Jul. 20	25.4	21.6	66	66	135	2.06	60.1	32.4	6.06	18.4	0.399	1.85		
		1969														
1970	25	May 15—May 24	25.3	20.2	58	64	116	1.82	57.8	32.1				1.82	Aug. 5,	previously
(A)	30	Jun. 6—Jun. 17	29.8	21.9	43	55	147	2.67	56.9	32.5				1.75	1968	reported
	32.5	Jun. 18—Jun. 28	32.4	24.6	44	51	191	3.75	55.4	32.4				1.71		(1970)[4]
	35	Jun. 29—Jul. 8	34.6	26.4	42	39	205	5.26	53.3	32.5				1.64		10
		1969														
1970	30	Jul. 9—Aug. 7	30.3	26.7	71	54	141	2.64	54.2	33.7				1.62	Aug. 5,	10
(B)	32.5	Aug. 8—Aug. 21	32.6	27.6	62	49	166	3.39	53.0	34.2				1.55	1968	
		1969														
	25	Dec. 20—Dec. 30	25.3	17.1	39	72	152	2.11	56.7	31.5				1.80		8
1971		1970													May 8,	previously
	30	Jan. 6—Jan. 16	29.9	19.6	33	58	169	2.78	56.2	31.0				1.81	1969	reported
	32.5	Jan. 17—Jan. 27	32.4	21.2	31	51	157	3.10	57.2	31.8				1.80		(1971)[5]
	35	Jan. 28—Feb. 6	34.6	22.1	28	39	159	4.06	56.7	33.2				1.71		

dry bulb temperatures were controlled between ±1°C in a temperature controlled room in the zootron of the Department of Animal Husbandry, Faculty of Fisheries and Animal Husbandry, Hiroshima University. Crushed oyster shells were given freely except in the 1970 Exp. (A) and (B).

RESULTS

Absolute value of food intake differed greatly in the same environment at 30°C (56 to 60% of RH), being 86g and 101 g, in the case of Experiment I and II respectively, but the weights corresponding to one kg of body weight were approximately the same, being 55 g and 57g. Food intake and water consumption were expressed as g per one kg of body weight.

As shown in Fig. 1, the food intake was approximately the same at 30°C of dry bulb temperature, being 54 to 58 g. Mean±standard deviation of food intake was 56±2g at 30±1°C of DBT. Irrespectively of the wide change of WBT from 19.6 to 27.5°C, the food intake rate remained constant,being about 56 g. The same phenomenon was also observed at 32.5°C irrespectively of the wide change of WBT from 21.2 to 29.6, and food intake rate per kg of body weight remained surprisingly constant, being 50 g. At 35°C, too, irrespectively of WBT change from 22.1 to 26.4°C, the food intake kept unchanged, being 39 g. But at 25°C the food intake varied largely and showed no clear tendency to change with WBT. On the whole, it was noticed that the increase of DBT brought about a decrease

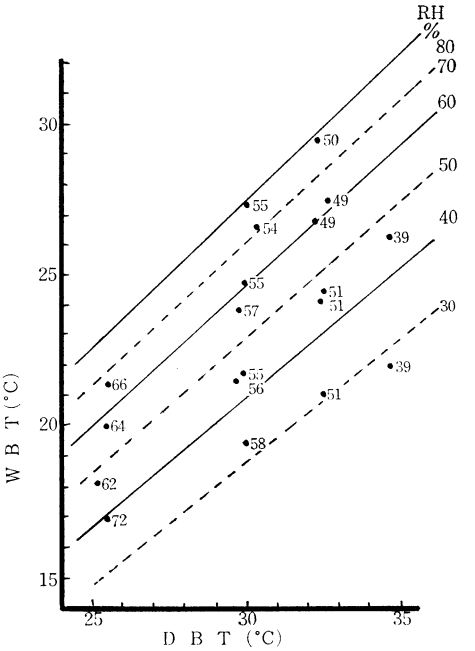

Fig. 1. Effect of humidity on food intake (g/kg).

in food intake of hens.

As shown in Fig. 2, with the change of WBT, there was not observed a definite tendency in water consumption at the same regime of DBT. At 25°C the mean value was 135±12 g/kg of body weight per day. On the other hand, it was 153±9, 174±15 and 182±23 g at 30, 32.5 and 35°C respectively. Water consumption showed a tendency to increase with DBT elevation.

Water/food intake ratio, as shown in Fig. 3, increased with DBT elevation. The mean value of this ratio at each temperature regime, was 2.05±0.15, 2.74 ±0.13, 3.47±0.32 and 4.67±0.59, at 25, 30, 32.5 and 35°C respectively. Based on a ratio at 25°C, it was 34% greater at 30°C, 69% at 32.5 and 128% greater at 35°C.

Egg weight, from the data in Exp. II and 1970 Exp. (A), had a tendency to decrease according to the temperature elevation. By a humidity elevation, egg weight seemed to decrease at 30 and 32.5°C, but as shown in Fig. 4, egg weight per kg of body weight seemed to increase slightly in accordance to the RH elevation. The mean value at each temperature was approximately the same, being 32.0, 33.0, 33.2 and 32.8 g, respectively at 25, 30, 32.5 and 35°C.

Though the examples are few, the change of egg shell thickness is shown in Fig. 5. The mean value has a tendency to decrease progressively at every higher

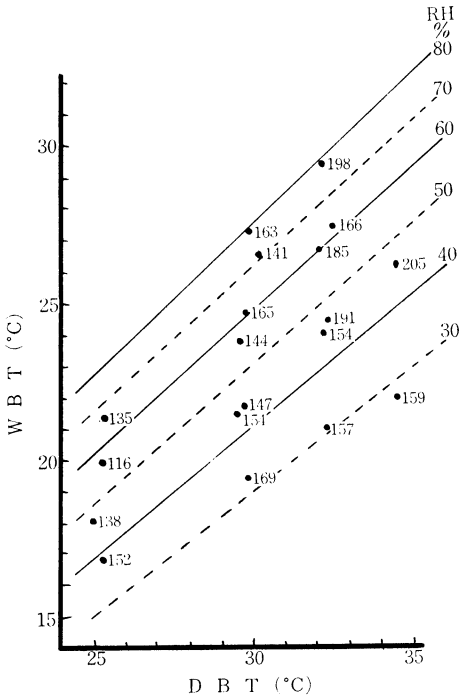

Fig. 2. Effect of humidity on water consumption (g/kg).

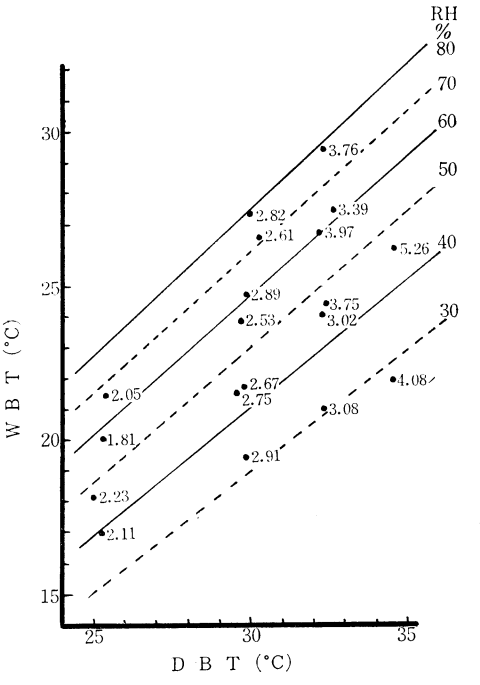

Fig. 3. Effect of humidity on water/food intake ratio.

temperature regime above 30°C. In each temperature regime, 0.391, 0.376 and 0.369 mm were obtained, respectively at 25, 30 and 32.5°C.

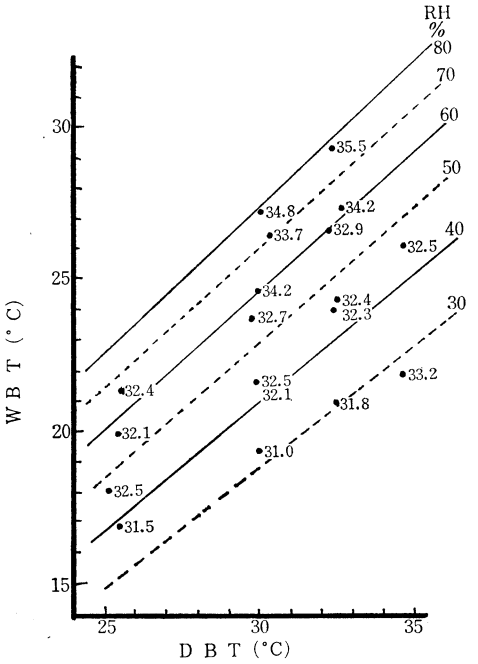

Fig. 4. Effect of humidity on egg weight (g/kg).

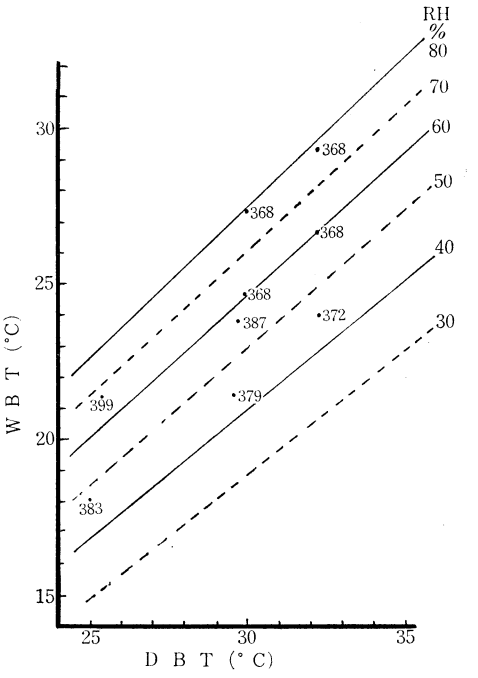

Fig. 5. Effect of humidity on egg shell thickness (1/1000 mm).

The egg shell weight definitely seemed to be connected with the egg size in Exp. I and II. The values of egg shell weight per egg per kg of body weight were constant in each DBT. In Exp. I, they were 15.2% at 30°C and 14.6% at 32.5°C. They were 18.4, 17.6 and 17.0% respectively at 25, 30 and 32.5°C in Exp. II.

DISCUSSION

Siegel and Drury (1968)[6] suggested that air movements above 0.5 m/sec. to 1 m/sec. of velocity has a reducing effect on respiration rates in chickens at 33°C. In our experiments air movements in the temperature room were constant, being about, 0.05 m/sec. at the portion of the cages. The air velocity in these experiments might have little effect on WBT even under higher temperature ranges. Therefore, the authors mainly discussed the point of humidity factors within the different components of WBT. Lee *et al.* (1945)[7] reported that the effect of humidity on rectal temperature was higher in Australorpes than in White Leghorns,

SIEGEL (1967)[3] reportethd at White Leghorns were better adapted to a humid environment, as reflected by only a small increase in rectal temperature over a wide range of humidities. The present results show the same tendency as the reports mentioned above, that White Leghorn hens adapt well to higher temperature under a wide range of humidities.

It will be noticed that food intake might be controlled by only DBT irrespectively of the change of WBT, especially in higher dry bulb temperature ranges.

Water/food intake ratio and water consumption were higher in a temperature above 32.5°C, and it became more increasing under the same DBT, with higher WBT. This may be due to the increase of the respiration rates, because the water requirement for egg production was constant or lesser but the requirement for the thermo-regulation of hens might have increased. The present results suggest, therefore, that humidity may be not effective on food intake, but affects the water consumption.

Since chickens are lacking sweat glands and the evaporation through the pores by perspiration does not seem considerable, evaporation through the mouth cavity and the trachea consequently is important at higher temperature regimes. These body parts have been considered as important elements in the heat dissipating system. We may take for sure that high humidity has a blocking effect on evaporaitve heat loss in higher RH (80–90%) at every high temperature regime (LEE *et al.*, 1945)[7]. HUTCHINSON (1955)[8] reported a decrease of evaporative loss as much as 33% under 73–83% of RH compared to that under 27% of RH at 34°C of DBT. Moderate humidity at higher temperature regime might increase respiration rates accompanied by increasing evaporative heat loss, and energy expenditure for panting. This may be indirectly a reason for body weight loss at higher temperature regimes.

SCHNEPEL and WARREN (unpublished)[9] reported a decrease of shell thickness of about 30 % from 21 to 32°C of elevation of environmental temperature. MUELLER (1961)[19] reported a decrease of 3.3 to 13% of shell thickness at 32°C compared to natural environment (8–27°C) accompanied by 15% decrease of food intake. In the present experiment the decreasing rate was 5.6% between 25 and 35°C regimes accompanied by 14% decrease of food intake.

Body weight differs according to the age of hens used in the experiments, in Exp. I it was 6 months old at the first stage of the experiment and 14, 9, 11 and 7 months old in Exp. II, 1970 Exp. (A), 1970 Exp. (B) and 1971 Exp. respectively. The precise conclusion, therefore, could not be reached but the fact that at low humidity below 40% RH, from 25 to 32.5°C ranges, body weight did not change, showed clearly. In medium or high humidity (above 40% RH), body weight decreased 0.06 kg during one period. From 32.5 to 35°C, in low or midium humidity, body weight decreased as much as 0.07 to 0.09 kg per period. These may be mainly due to the decrease of food intake as mentioned above and to the results of the metabolic adaptation. The decreasing rate of each food intake per one kg of body weight along 1°C of DBT elevation was evaluated as follows;

at the temperature from 25 to 32.5°C it was 3 to 4% and from 32.5 to 35°C went up to 9%/°C.

The decrease of egg weight was coincident with Huchinson's report (1953)[11] at higher temperature regimes, though the effect of the humidity was not so clear. Egg weight per one kg of body weight increased slightely together with the humidity elevation, this may be in relation to the decrease of body weight mentioned above.

The values of egg shell weight/egg weight/kg of body weight were constant in each DBT and in each experiment. These were assumed to be due to the decreasing rate of the egg shell, the whole egg and body weight which constantly changed together with the DBT changes.

The order of influences of environmental temperatures and humidities on food intake, body weight and egg weight may be considered as follows. The decrease of food intake comes first followed by body weight and egg weight decrease.

SUMMARY

The present research work was performed in view of investigating the effects of humidity, under the several DBT and changes of WBT, on food intake, water consumption and egg shell quality in White Leghorns based on a series of experiments. Twenty-four laying hens were kept in a temperature controlled room under 30 and 32.5°C at 60 and/or 80% RH during 3 weeks in Experiment I; and under 25, 30 and 35°C at lower humidity in Exp. II.

For confirmation, previously reported 1970 Exp. (A) and more humid 1970 Exp. (B) (unpublished, 30 and 32.5°C, 60–70% RH) and previously reported 1971 Exp. were compared to the present data. The results obtained were as follows.

1) Each food intake per 1 kg of body weight, irrespectively of wide change of WBT and controlled by DBT, was surprisingly constant especially under higher temperature ranges.

2) Water consumption, egg weight and egg shell thickness also seemed to be controlled mainly by DBT.

3) The body weight may have a tendency to be affected by humidity in relation to evaporative system as to the thermo-regulation in chickens.

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白レグの産卵，採食，飲水におよぼす環境温度の影響

Ⅲ．湿度の影響について

伊藤　敏男・尾崎　勉・宍戸　裕・三村　耕

白レグ産卵鶏24羽を用い，実験（Ⅰ）は乾球温度30および 32.5°C で RH60 又は 80%で，実験（Ⅱ）は同じ鶏で 25～32.5°C 低湿条件で行ない，さらに以下の実験をとりまとめ，1971 実験(A) 25～35°C（既報）および同じ鶏で高湿で1971 実験(B)と1970・実験25～35°C（既報）について，湿度が採食，飲水，卵かくにおよぼす影響を調査し，次の知見を得た．

1）体重あたりの採食量は湿球温度の変化（RHの変化）に関係なく，ほぼ乾球温度により影響（高温で減少）をうけた．

2）飲水量，卵重，卵かくの厚さも同様に乾球温度により影響をうけた．（高温で飲水量大，卵重・卵かくのあつさの低下）

3）高温における体重減少は，鶏の体熱放散機構からみて湿度が関与しているかもしれない．