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Hematocrit and Hemoglobin of Broilers as Influenced by Environmental Temperature and Dietary Iron Level

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ABSTRACT Two experiments were conducted to study the effect of environmental temperature on hematocrit and hemoglobin values of chicks receiving diets containing various levels of copper (Cu) and iron (Fe). Hematocrit and hemoglobin values were affected by environmental temperature and dietary Cu and Fe level. A significant increase in hemoglobin values was obtained with increasing Cu and Fe levels at both temperatures. The hematocrit values followed the same pattern with the exception of the 19-day-old birds reared at 21.1°C. and receiving the highest Cu and Fe diet. Hemoglobin values of birds reared at 21.1°C. receiving the basal diet supplemented with 2 p.p.m. Cu and 20 p.p.m. Fe were the same as the hemoglobin values of birds reared at 32.2° C. receiving the basal diet supplemented with 9 p.p.m. Cu and 90 p.p.m. Fe. Within each dietary regime, birds reared at 21.1°C. had significantly higher hematocrit and hemoglobin values than birds reared at 32.2°C., with the exception of the hemoglobin values for birds receiving the basal diet.

Chicks reared from 1 day of age to 2 weeks of age in a conventional manner responded to dietary Fe level and environmental temperature within a 2-week period. Within each dietary regime, hematocrit and hemoglobin values for birds reared at 10°C. were significantly higher than for birds reared at 21.1° C. Hematocrit and hemoglobin values for birds reared at 32.2°C. were significantly lower than the other two temperatures. A comparison between temperatures for the combined diets shows a decrease in hematocrit and hemoglobin values as the temperature at which birds are reared is increased.

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INTRODUCTION

SEVERAL researchers have shown that the environmental temperature at which broilers are reared may influence hematocrit and hemoglobin values. Olson (1937) found that the number of erythrocytes in the domestic fowl increased during the winter. Huston (1960) reported an increase in erythrocyte concentration and hematocrit for birds reared at 21.1°C. when compared to birds reared at 30.0°C. Huston (1965) observed that hematocrit values from birds reared at a constant temperature of 30.0°C. were significantly lower than birds reared at 8.0° and 19.0°C. No significant difference was found between the hematocrit values from birds reared at 8.0°C. and 19.0°C. Deaton *et al.* (1969a) reared birds at constant temperatures of 7.2°, 15.6°, 23.9° and 32.2°C. and observed that 8-week hematocrit and hemoglobin values were highest for the birds reared at 7.2°C.

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and lowest for the birds reared at 32.2°C. Deaton *et al.* (1969b) reared chicks from 1 day to 56 days of age at constant temperatures of 7.2°, 23.9° and 32.2°C. With the exception of the first week, birds reared at the 7.2°C. temperature had significantly higher hematocrit and hemoglobin values than the birds reared at 32.2°C. There were no consistent significant differences in hematocrit or hemoglobin values for the birds reared at 23.9° and 32.2°C.

Washburn and Huston (1968) fed a synthetic milk diet with 3 levels of copper (Cu) and iron (Fe) to chicks reared at temperatures of 8.0°, 19.0° and 30.0°C. They reported a distinct effect of environmental temperature on all dietary regimes, but the effect was not clear cut when examined within a dietary treatment.

The objective of the research reported herein was to study the effect of environmental temperature on hematocrit and hemoglobin values of broilers receiving diets containing various levels of Cu and Fe.

EXPERIMENTAL PROCEDURE

Experiment 1. In two trials, mixed-sex commercial broiler chicks 1 day of age were placed in batteries in environmental chambers and the temperature maintained at 32.2°C. for 24 hours. The temperature in one chamber was then established over a 6-hour period at 21.1°C. and maintained for the 26-day experimental period. The temperature in the second chamber was maintained at 32.2°C. for the 26-day experimental period. The basal diet (Table 1) which was fed to one group was a modification of the diet of Featherston *et al.* (1968). Atomic absorption analysis of the basal diet demonstrated it contained 3 p.p.m. Cu and 15 p.p.m. Fe. The other two groups received diets supplemented with 2 p.p.p. Cu and 20 p.p.m. Fe or 9 p.p.m. Cu and 90 p.p.m. Fe. For each of the two trials, three replicates of 10 males and 10 females at each temperature received one of the three diets. In each trial, at 19 and 26 days of age, 4 males and 4 females from each replicate were randomly selected and venous blood collected. The microhematocrit technique was used for hematocrit determinations. Hemoglobin content was obtained by using the method of Lucas and Jamroz (1961). All measurements were made on individual birds.

Experiment 2. Commercial male broiler chicks were reared from 1 day to 2 weeks of age as a group using standard brooding practices. They received a basal starter diet containing approximately 23.3 percent protein and having a metabolizable energy value of 3285 kilocalories per kilogram. At 2 weeks of age, they were placed in batteries in one of three environmental chambers maintained at 10.0°, 21.1° and 32.2°C. They were fed the basal diet supplemented with 0 p.p.m. Cu and 0 p.p.m. Fe or 9 p.p.m. Cu and 90 p.p.m. Fe. At 28

TABLE 1.—*Composition of basal diet*

Ingredient	Percent
Dried skimmilk	63.00
Sucrose	15.38
Mineral premix[1]	6.07
Vitamin premix[2]	1.00
Vegetable oil	13.00
DL methionine	0.30
Glycine	0.50
L-arginine-HCl	0.50
Choline chloride (70%)	0.20
Butylated hydroxytoluene (25%)	0.05

[1] The mineral premix provided the following reagent minerals in g./kg. of diet: $CaCO_3$, 19.10; $Ca(H_2PO_4)_2 \cdot H_2O$, 21.15; K_2HPO_4, 11.20; NaCl, 6.0; $MgCO_3$, 2.50; $ZnCO_3$, 0.18; $MnSO_4 \cdot H_2O$, 0.51; $CuSO_4 \cdot 5H_2O$, 0.015; KI, 0.04; $Na_2MoO_4 \cdot 2H_2O$, 0.0025.

[2] The vitamin premix provided the following units of vitamins per kg. of diet: (in milligrams) riboflavin, 9; thiamin·HCl, 6; Ca D-pantothenate, 20; niacin, 50; pyridoxine·HCl, 8; folic acid, 2; biotin, 0.3; menadione sodium bisulfite, 2; inositol, 1000; and vitamin B_{12}, 20 μg.; and vitamin A, 25,000 U.S.P. units; vitamin D_3, 1,200 I.C.U.; vitamin E, 17.6 I.U.

days of age, blood was collected and hematocrit and hemoglobin values were determined.

Statistical examinations of the data by analysis of variance were performed in accordance with the procedure described by Steel and Torrie (1960). Significant treatment means were separated by using the multiple range test of Duncan (1955).

RESULTS

Experiment 1. The results of Experiment 1 are presented in Table 2. Within each temperature, birds receiving the basal diet with no added Cu and Fe had significantly lower hematocrit and hemoglobin values than birds receiving the diets supplemented with Cu and Fe. A significant increase in hemoglobin values was obtained with increasing Cu and Fe levels at both temperatures. With the exception of the 19-day-old birds reared at 21.1°C., birds receiving the basal diet supplemented with 9 p.p.m. Cu and 90 p.p.m. Fe had significantly higher hematocrit values than birds receiving the basal diet supplemented with 2 p.p.m. Cu and 20 p.p.m. Fe.

Hemoglobin values of birds reared at 21.1°C. receiving the basal diet supplemented with 2 p.p.m. Cu and 20 p.p.m. Fe were the same as the hemoglobin values of birds reared at 32.2°C. receiving the basal diet supplemented with 9 p.p.m. Cu and 90 p.p.m. Fe. Within each dietary regime, birds reared at 21.1°C. had significantly higher hematocrit and hemoglobin values than birds reared at 32.2°C., with the exception of the hemoglobin values for birds receiving the basal diet. When a comparison is made between temperatures for all dietary treatments combined, the hematocrit values were 6.17 higher and the hemoglobin values were 0.75 higher at 21.1°C. than at 32.2°C.

Experiment 2. The results of Experi-

TABLE 2.—*Effect of environmental temperature and dietary iron level on hematocrit and hemoglobin values of mixed-sex broilers*

Criteria	Temperature (°C.)					
	21.1			32.2		
	Dietary Treatment[1]					
	Basal+0, 0 p.p.m. Cu, Fe	Basal+2, 20 p.p.m. Cu, Fe	Basal+9, 90 p.p.m. Cu, Fe	Basal+0, 0 p.p.m. Cu, Fe	Basal+2, 20 p.p.m. Cu, Fe	Basal+9, 90 p.p.m. Cu, Fe
Hematocrit (19 days of age)	26.88a[2]	34.33c	35.22c	18.21d	27.92a	31.38b
Hematocrit (26 days of age)	25.07a	33.50d	35.51e	19.71f	27.12b	29.13c
Hemoglobin (19 days of age)	7.87a	9.80c	10.65d	7.29a	8.75b	9.68c
Hemoglobin (26 days of age)	7.42a	9.16c	9.77d	7.18a	8.25b	9.03c
	Mean of 21.1° temperature			Mean of 32.2° temperature		
	Hematocrit 31.75 Hemoglobin 9.11			Hematocrit 25.58 Hemoglobin 8.36		

[1] Basal diet initially contained 3 p.p.m. Cu and 15 p.p.m. Fe.

[2] Between each temperature and dietary treatment, within each criterion, values having the same letters are not significantly different at the .05 level of probability.

TABLE 3.—*Effect of environmental temperature and dietary iron level on hematocrit and hemoglobin values of male broilers*

Criteria	Temperature (°C.) 10.0		21.1		32.2	
	Dietary Treatment[1]					
	Basal+0, 0 p.p.m. Cu, Fe	Basal+9, 90 p.p.m. Cu, Fe	Basal+0, 0 p.p.m. Cu, Fe	Basal+9, 90 p.p.m. Cu, Fe	Basal+0, 0 p.p.m. Cu, Fe	Basal+9, 90 p.p.m. Cu, Fe
Hematocrit	32.10a[2]	39.40c	26.40e	35.10b	23.80f	29.60d
Hemoglobin	7.64a	10.50c	6.83d	8.81b	6.12e	7.91a
	Mean of 10.0° temperature		Mean of 21.1° temperature		Mean of 32.2° temperature	
	Hematocrit 35.75 Hemoglobin 9.07		Hematocrit 30.75 Hemoglobin 7.82		Hematocrit 26.70 Hemoglobin 7.02	

[1] Basal diet initially contained 3 p.p.m. Cu and 15 p.p.m. Fe.
[2] Between each temperature and dietary treatment, within each criterion, values having the same letters are not significantly different at the .05 level of probability.

ment 2 are presented in Table 3. Within each temperature, significant increases in hematocrit and hemoglobin values were obtained for the birds receiving the basal diet supplemented with 9 p.p.m. of Cu and 90 p.p.m. of Fe. When a comparison is made between temperatures, within each dietary regime birds reared at 10.0°C. had significantly higher hematocrit and hemoglobin values than birds reared at 21.1°C. Within each dietary regime, hematocrit and hemoglobin values for birds reared at 32.2°C. were significantly lower than the other two temperatures. A comparison between temperatures for the combined diets shows a decrease in hematocrit and hemoglobin values as the temperature at which birds are reared is increased. These results also demonstrate that 1-day-old birds can be reared in a conventional manner for a 2-week period and within 2 weeks a response to dietary Fe level and environmental temperature can be obtained.

DISCUSSION

Results obtained in these experiments are in general agreement with other researchers in that higher hemoglobin and hematocrit values were obtained at lower environmental temperatures. Olson (1937) found that the number of erythrocytes in the domestic fowl increased during the winter. Huston (1960) reported an increase in erythrocyte concentration and hematocrit for birds reared at 21.1°C. when compared to birds reared at 30.0°C. Deaton *et al.* (1969a, b) observed significantly higher hematocrit values for birds reared at 7.2°C. than for birds reared at 32.2°C., but no consistent significant differences in values for the birds reared at 23.9° and 32.2°C. Results obtained in Experiment 1 (Table 2) show significantly higher hematocrit values within each diet and for all diets combined for birds reared at 21.1°C. when compared to birds reared at 32.2°C. Hemoglobin values followed the same pattern except for the birds receiving the basal diet without Cu and Fe supplementation, which were not significantly higher at 21.1°C.

Huston (1965) observed that hematocrit values for birds reared at a constant temperature of 30°C. were significantly lower than birds reared at 8.0° and

19.0°C., but no significant difference was found between the hematocrit values for birds reared at 8.0° and 19.0°C. The results obtained in Experiment 2 (Table 3) show significantly higher hemoglobin and hematocrit values for birds reared at 10.0°C. when compared to birds reared at 21.1°C. Higher hemoglobin and hematocrit values were observed for the birds reared at 21.1°C. when compared to the birds reared at 32.2°C.

Washburn and Huston (1960) fed a synthetic milk diet with 3 levels of copper and iron to chicks reared at temperatures of 8.0°, 19.0° and 30.0°C. They reported a distinct effect of environmental temperature on the combined dietary regimes, but the effect was not clear cut when examined within a dietary regime. The results presented in Tables 2 and 3 show a dramatic temperature effect on hematocrit values within each dietary regime and for the dietary regimes combined.

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NEWS AND NOTES

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quences of family selection and progeny testing.

1:55–2:35 C. R. Henderson—Sire Evaluation and Genetic Trends. Dr. Henderson, a student of Dr. Lush, will trace developments in Dairy Sire Evaluation from the early daughter-dam procedures developed by Lush to the present procedures for which Dr. Henderson is himself largely responsible.

2:35–3:00 Break

3:00–3:40 A. B. Chapman—Selection Theory and Experimental Results. Dr. Chapman, a former student of Dr. Lush, will review principles of selection theory, much of which has been developed and discussed by Dr. Lush, relative to pertinent experimental results testing this theory.

3:40–4:20 G. E. Dickerson—Inbreeding and Heterosis in Animals. Dr. Dickerson, a former colleague of Dr. Lush while with the Regional Swine Breeding Laboratory from 1941 to 1947, will review contributions of Dr. Lush on utilization of inbreeding and teterosis and present original material.

4:20–5:00 Jay L. Lush—Teaching Animal Breeding and Training Graduate Students.

6:30–7:30 Banquet

7:30–7:45 L. N. Hazel—Chairman.

7:45–8:45 R. W. Touchberry—The Life and Contributions of Dr. Jay L. Lush. Dr. Touchberry will discuss Dr. Lush, the man, the educator and the scientist.

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