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Rate and Efficiency of Gains in Beef Cattle

VII. Hematology of Growing Hereford and Angus Calves

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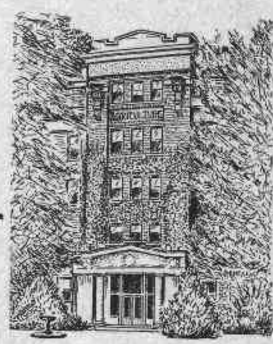

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VII. Hematology of Growing Hereford and Angus Calves

Introduction

Blood, which serves as a very useful index of the physiological state of the animal, is also the most readily accessible portion of the living animal. Many of the changes occurring in various parts of the animal are reflected in blood composition. Knowledge of normal blood composition is a preliminary necessity for the interpretation of results employing cattle as experimental animals, or as an aid in veterinary diagnosis. A knowledge of the causes of variation in normal blood composition of cattle is also important as an aid in precise use of hematology in bovine research. Calves on performance test in the Oregon State College beef cattle herd were used as subjects to give normal hematological values and to determine what hematological changes occur in relation to age and growth rate while the calves are on feed test.

Review of Literature

No attempt has been made to cover all areas of hematology, and only those references pertinent to the present investigation are quoted. A most helpful source of information has been the manual, "Standard Values in Blood," edited by Albritton (1952). Means, ranges, and standard errors have been presented in this manual, as well as references to the literature from which the information was gathered.

Red Blood Cells

From compilations of information of several investigators, Coffin (1953) reported a red blood cell count ranging from 5.4 to 9.0 million per cu. mm. for cattle. Dukes (1955) gave an overall mean of 6.3 million per cu. mm. and a range of 4.90 to 9.79 per cu. mm. calculated from 144 samples on six dairy cows. Ferguson (1954) observed a mean of 6.33 million per cu. mm. with a range of 5.64 to 7.44 million per cu. mm. for dairy cattle.

Rusoff (1946) gave the following means for red blood counts on dairy cows: Jerseys 6.55, Guernseys 7.49, and Holsteins 7.84 million per cu. mm.

For red blood cell counts of dairy calves from birth to one year old, Greatorex (1954) reported the following values:

Age	Mean counts
At birth	7.4 millions per cu. mm.
1 week	7.5 millions per cu. mm.
8-12 weeks	8.1 millions per cu. mm.
4-6 months	7.8 millions per cu. mm.
12 months	7.5 millions per cu. mm.

Long *et al.* (1952) studied the composition of blood taken from Hereford, Angus, and Shorthorn beef cattle. All the breeds had a normal variation from 4.5 to 6.0 million red blood cells per cu. mm. This seems low when compared with data on dairy cattle. The difference may be due to the indirect turbidity technique used in determining the red cell count.

Cornelius (1956) found, from data on 38 Hereford and Angus dwarf cattle ranging in age from 6 days to 14 months, a mean red cell count of 9.8 ± 1.6 million per cu. mm.

Long and coworkers (1952) found no breed difference between Hereford, Angus, and Shorthorn beef cows for blood hemoglobin content. Cornelius (1956) determined blood hemoglobin values for dwarf beef cattle and concluded that a mean value of 11.7 ± 1.4 gm. of hemoglobin per 100 ml. of blood was within the normal range for the bovine species.

MacDonald, Krueger, and Bogart (1956) reported an average value of 12.0 gm. of hemoglobin per 100 ml. of blood for Hereford and Angus beef calves on performance test at 500 and 800 pounds body weight. Blood hemoglobin on the average was higher in females than in males, and this was especially true in Angus calves. Average blood hemoglobin was higher in Angus than in Herefords for both males and females.

Price and coworkers (1956) showed that hemoglobin at 800 pounds body weight was positively related to feed consumed per 100 pounds gain during the feed test, whereas at 500 pounds the correlation was not significant.

Wintrobe (1942) developed ratios to describe mean corpuscular hemoglobin content and mean corpuscular volume. In addition, he described mean corpuscular hemoglobin concentration as the percentage of hemoglobin of the corpuscular volume. The mean corpuscular hemoglobin portrays the ratio between amount of hemoglobin and number of red cells in the blood, expressed in number of grams of hemoglobin per red blood cell x 10^{-12}. The mean corpuscular volume value shows the ratio between the volume of packed cells and the number of red cells in the hematocrit tube. It is a measure of the volume of the individual erythrocyte. The mean corpuscular volume is expressed in cubic microns. Mean corpuscular hemoglobin concentration expresses, in percentage, the relationship between the hemoglobin in grams and the mean corpuscular volume in cubic microns and gives the quantity of hemoglobin per red cell.

Normal ranges reported on cattle by Coffin (1953) are 14.4 to 18.6 micromicrograms for mean corpuscular hemoglobin, 49.5 to 60.7 cubic microns for mean corpuscular volume, and 32% to 34% for mean corpuscular hemoglobin concentration.

Albritton (1952) gives a range of 14.2 to 18.5 micromicrograms with a mean of 15.7 micromicrograms for corpuscular hemoglobin content of the blood of the adult cow. The mean corpuscular volume ranged from 47 to 54 cubic microns with a mean of 50.0 cubic microns.

Greatorex (1954) calculated the mean corpuscular volume on 233 dairy calves from birth to one year of age. The extreme values were 28 to 112 cubic microns whereas the mode was from 40 to 60 cubic microns and individual values were evenly distributed throughout the first 12 months of life. The mean corpuscular hemoglobin concentration of the majority of calves ranged from 21% to 40%.

White Blood Cells

Greatorex (1954) found the number of leucocytes per cu. mm. of blood, in dairy calves from birth to a year of age, ranged between 4,500 and 15,000, with the majority ranging from 6,500 to 11,500 per cu. mm.

In dairy cows Hayden and Fish (1928) reported an average total leucocyte count of 9,034 per cu. mm. of blood; Ferguson (1945) 8,912 per cu. mm.; Rusoff (1946) a range of 8,411 to 10,268 per cu. mm.; and Brody (1949) 8,570 per cu. mm. of blood. Rusoff (1954) reported 8,580 per cu. mm. of blood in dairy bulls.

Recent investigations related to bovine dwarfism have attempted to use leucocyte counts as one of the criteria for determining breeding animals which carry the dwarf gene. Cornelius (1956) found that all hematological values appeared normal with the exception of the differential leucocyte count. The total white cell count average of 8,800 per cu. mm. was within normal range for the bovine. Several state experiment stations have made use of the total white cell count while conducting investigations on detection of the dwarf-carrier animal. According to Schneider (1957) a relatively simple and inexpensive test for identifying dwarf-carrier animals is being developed by Lasley of the University of Missouri. This test uses insulin injections as a means of placing animals to be tested under a so-called "stress" condition. Such injections bring a marked and rapid increase in the number of white blood cells in the blood stream of the dwarf-free or "clean" animal. Reaction in the dwarf-carrier animals is noticeably slower and weaker. The white blood cell count of a dwarf animal increases very little and at a very slow rate.

Coffin (1953) gives normal ranges and means for differential white cell counts of cattle. Neutrophils range from 15 to 55, with a mean of 30%; eosinophils range from 1 to 15, with a mean of 8%; basophils range from 0 to 1, with a mean of 0.5%; lymphocytes range from 40 to 70, with a mean of 52%; and monocytes range from 3 to 15, with a mean of 9%.

Methods and Procedure

Data presented in this investigation were taken from 45 beef calves maintained at the Oregon Agricultural Experiment Station at Corvallis. The beef herd comprises two breeds, Hereford and Angus. The Hereford groups are made up of three closed lines of approximately 15 cows in each line while the Angus unit comprises approximately 20 cows in a closed line. The Hereford lines are designated as the Lionheart, Prince, and David lines.

Management

Management procedures used and recommended by Dahmen and Bogart (1952) were followed and the calves were fed a completely pelleted ration composed of 2 parts chopped alfalfa and one part concentrate (Nelms, Williams, and Bogart, 1953).

Blood Collection

Blood samples were collected at 500 pounds and 800 pounds body weight. Either 13 or 15 gauge bleeding needles were used. One sample of about 6 ml. was collected into an oxalated tube to prevent coagulation as recommended by Washko (1948).

The blood samples were obtained from test calves about 9:00 a.m. to 10:00 a.m. and counting procedures, hemoglobin, and hematocrit determinations were initiated immediately.

Cellular Components

Hematocrit. Six milliliters of blood were placed into a 15 ml. graduated centrifuge tube, containing potassium oxalate. The tubes were placed in an International No. 2 centrifuge and spun at 3,000 revolutions per minute for 45 minutes. After centrifugation the volume of packed cells and total volume were determined to the nearest 0.1 of a milliliter. A percentage value for the hematocrit was calculated as (100 x ml. of red cells) / (ml. of total volume).

Total red blood cell count. Oxalated venous blood was used. Standard red blood cell counting pipettes and Spencer counting chambers with improved Neubauer double rulings were employed. The blood was diluted in the pipette 1 to 200 with Hayem's solution

(Coffin 1953). After dilution the blood cells were dispersed in the Hayem's solution by placing the pipettes containing the sample in a mechanical shaker for 3 minutes. The technique for mounting the blood sample and counting is described in detail by Osgood (1937). Samples were counted in duplicate and the average taken. According to Plum (1936), error in counting depends more on the total number of cells counted than on the area. From the results of Plum's investigation, this laboratory concluded that counting 600 or more cells was sufficient. The accuracy of determinations made on oxalated blood deteriorates after certain time intervals, and the limits given by Osgood (1940) were noted. The red cell count was performed within 24 hours after collection.

Total white blood cell count. Essentially the same technique used in the red cell count was applied to white cell counting. Oxalated blood was used and diluted 1 to 20 with standard white blood cell diluting pipettes. Turk's solution was used for diluting the blood cells as described by Zoethout (1948). A Levy leucocyte counter with Fuchs-Rosenthal double ruling was employed. Again, as for red cell counting, accuracy depends on the total number of cells counted. With Turk's solution dark dots representing stained nuclei of white cells are counted. The cytoplasm of white cells becomes transparent and red cells are destroyed by acid in the diluting fluid. Counts were performed in duplicate and the average value taken as the individual observation.

Differential white cell count. The differential white cell count was made by spreading blood in a thin film on a clean slide, fixing it, and staining with Wright's differential stain (Osgood, 1940). The slide was then examined under an oil immersion lens and white cells classified as seen until 100 were counted. The majority of the cells were classified as lymphocytes, eosinophils, neutrophils, basophils, monocytes, and stab cells.

Statistical Analyses

Data were analyzed by standard statistical techniques as outlined by Li (1957). Means, standard errors, ranges, and correlations have been reported. Data have been broken down by sex, breed, and line.

Experimental Findings

Performance information on each animal included average rate of gain on feed test (rate of gain), average feed consumed per 100 pounds gain, and age in days at 500 and 800 pounds body weight. These data are presented in Tables 1 and 2 for reference purposes. For a full discussion of their significance the reader is referred to Price *et al.* (1956).

As detailed in the previous section, the following blood data have been assembled: hemoglobin concentration, hematocrit percentage, red cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, total white cell count, lymphocyte count, neutrophil count, monocyte count, and eosinophil and basophil counts. These are presented in Tables 3-8. Correlations between the blood constituent and feedlot performance data of test calves have been calculated. Also correlations between the same blood constituent at 500 and 800 pounds body weight have been determined to give an estimation of the repeatability of blood values.

Differences between means for group comparisons have been tested statistically by Student's "t" test, with significant differences being chosen at probabilities of 0.05 or less.

Blood Hemoglobin

The mean blood hemoglobin level of all calves at 500 pounds body weight was 12.1 gm. per 100 ml. blood (Table 3). The level of 11.8 gm. per 100 ml. for all male calves was significantly less than the level of 12.4 gm. per 100 ml. for all females ($P < 0.05$). Hereford males also had a hemoglobin level of 11.5 gm. per 100 ml. which was significantly less than that of Hereford females ($P < 0.01$).

In the comparison between breeds, Hereford males were found to have a significantly lower hemoglobin level than Angus males which had a level of 12.7 gm. per 100 ml. ($P < 0.01$).

Table 1. AVERAGE AGE OF CALVES AT 500 AND 800 POUNDS BODY WEIGHT

Group	Number of calves	Age at 500 pounds		Age at 800 pounds	
		Average	Range	Average	Range
		days	*days*	*days*	*days*
Lionheart males	5	236	213-274	350	311-379
Lionheart females	1	224		378	
Prince males	5	244	195-305	349	325-387
Prince females	6	249	218-300	394	369-447
David males	5	251	233-271	359	346-377
David females	5	238	244-318	424	353-474
Hereford males	15	244	195-305	352	311-387
Hereford females	12	262	218-318	405	353-474
Angus males	5	235	210-261	352	329-372
Angus females	12	244	205-386	403	345-461
All males	20	242	195-305	352	311-387
All females	24	253	205-318	404	345-474
All animals	44	248	195-318	380	311-474
Standard error of the mean for all animals		±4.4		±5.8	

Table 2. AVERAGE RATE OF GAIN AND POUNDS OF FEED CONSUMED PER 100 POUNDS GAIN OF CALVES FROM 500 POUNDS TO 800 POUNDS BODY WEIGHT

Group	Number of calves	Rate of gain per day		Feed consumption per unit gain	
		Average	Range	Average	Range
		pounds	*pounds*	*pounds*	*pounds*
Lionheart males	5	2.73	2.34-3.03	703	639-752
Lionheart females	1	2.06		937	
Prince males	5	2.91	2.25-3.78	621	554-669
Prince females	6	2.27	1.99-2.89	842	722-937
David males	5	2.83	2.57-3.12	704	644-742
David females	5	2.14	1.83-2.68	947	784-1002
Hereford males	15	2.83	2.25-3.78	676	554-752
Hereford females	12	2.20	1.83-2.89	894	722-1002
Angus males	5	2.64	2.28-2.93	775	659-851
Angus females	12	1.96	1.66-2.24	1044	895-1238
All males	20	2.78	2.25-3.78	701	554-851
All females	24	2.08	1.66-2.89	969	722-1238
All animals	44	2.40	1.66-3.78	847	554-1238
Standard Error of the mean for all animals		±0.07		±26.1	

No significant differences in hemoglobin level of the groups were recorded at 800 pounds body weight. There was a correlation coefficient of 0.35 between the hemoglobin levels at 500 and 800 pounds body weight ($P < 0.05$) indicating that, while there was considerable variation, there was a relationship between the two levels.

Hematocrit

The average hematocrit reading of all calves at 500 pounds body weight was 40.3% (Table 3). The only sex difference recorded was in Prince calves in which the average hematocrit of 38.0% for Prince males was significantly lower than that of Prince females ($P < 0.05$).

While no overall sex differences were recorded in the hematocrit levels at 800 pounds body weight, David males had significantly lower levels than David females. The difference of 3.7% was significant at the 1% level. When the two breeds were compared, Hereford males were found to have a level of 42.2% which was significantly lower than the Angus male hematocrit reading of 47.0%.

The repeatability of the readings at 500 and 800 pounds body weight was low ($r = 0.19$).

Table 3. Average Hemoglobin and Hematocrit of the Calves at 500 and 800 Pounds Body Weight

Group	Hemoglobin				Hematocrit			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	gm./100 ml.	*gm./100 ml.*	*gm./100 ml.*	*gm./100 ml.*	*percent*	*percent*	*percent*	*percent*
Lionheart males	11.4	(10.8-11.9)	13.0	(12.6-13.4)	40.3	(35.6-50.0)	43.7	(37.10-50.5)
Lionheart females	12.7		13.1		40.0		38.6	
Prince males	11.4	(10.8-12.1)	12.8	(12.6-13.0)	38.0	(32.8-41.3)	40.0	(37.3-45.5)
Prince females	12.4	(11.3-14.0)	13.1	(12.3-13.7)	43.3	(40.2-46.7)	42.9	(36.4-50.0)
David males	11.7	(11.2-12.0)	12.8	(11.3-14.7)	38.6	(33.9-40.3)	41.9	(40.0-44.6)
David females	12.3	(10.5-13.7)	13.0	(11.8-14.3)	39.5	(31.5-46.2)	45.6	(41.7-49.4)
Hereford males	11.5	(10.8-12.1)	12.9	(11.3-14.7)	39.0	(32.8-50.0)	42.2	(37.1-50.5)
Hereford females	12.4	(10.5-14.0)	13.1	(11.8-14.3)	41.5	(31.5-46.8)	43.7	(36.4-50.0)
Angus males	12.7	(12.2-13.6)	13.6	(12.8-15.0)	41.9	(37.1-48.3)	47.0	(40.7-53.9)
Angus females	12.4	(10.9-14.0)	13.6	(11.7-14.4)	40.2	(31.8-46.0)	45.2	(35.3-53.6)
All males	11.8	(10.8-13.6)	13.1	(11.3-15.0)	39.7	(32.8-50.0)	43.4	(37.1-53.9)
All females	12.4	(10.5-14.0)	13.3	(11.7-14.4)	40.8	(31.5-46.8)	44.5	(35.3-53.6)
All animals	12.1	(10.5-14.0)	13.2	(11.3-15.0)	40.3	(31.5-50.0)	44.0	(35.3-53.9)
Standard error of the mean for all animals	±0.14		±0.12		±0.67		±0.70	

Red Cell Count

The overall average red cell count for all calves at 500 pounds was 7.70 million per cubic millimeter. No dissimilarities were found in red cell count between sexes or between breeds or lines. A similar situation prevailed at 800 pounds body weight. It is interesting to note that the repeatability of the counts at the two weights was fairly high ($r = .33$) so that the lack of differences cannot be attributed to extreme variability of counts. Rather, it would seem that red cell count was not influenced by sex or line.

Mean Corpuscular Volume

The mean corpuscular volume of all calves at 500 pounds body weight was 52.6 cubic microns (Table 4), while at 800 pounds body weight the mean corpuscular volume of all the calves was 53.7 cubic microns. No line or sex differences in this constituent were observed at either body weight.

Mean Corpuscular Hemoglobin

The mean corpuscular hemoglobin of all the calves at 500 pounds body weight was 15.9 micromicrograms, and at 800 pounds body weight was 16.1 micromicrograms. As in the case of the mean corpuscular volume, no sex or line differences were observed at either 500 or 800 pounds body weight (Table 5).

Mean Corpuscular Hemoglobin Concentration

At both 500 and 800 pounds body weight, the mean corpuscular hemoglobin concentration for all calves was 30.3% (Table 5). No sex or line differences for this constituent were recorded.

White Cell Count

At 500 pounds body weight, average white cell count for all calves was 9,850 cells per cubic millimeter (Table 6). Males had an average of 10,090 cells per cu. mm. which was significantly greater than the level of 9,659 cells per cu. mm. of females ($P < 0.01$). Angus males also had a significantly higher concentration of white cells than Angus females averaging 1,840 cells per cu. mm. more than the females ($P < 0.01$).

In the comparison between breeds, Angus males had a higher level than Hereford males ($P < 0.05$) and within the Hereford lines both Lionheart and David male calves had cell counts higher than that of Prince male calves ($P < 0.05$).

When calves were again compared at 800 pounds body weight, the average for all animals had fallen slightly to 9,410 cells per cu. mm. (Fig. 1). Once again Angus male calves had a higher white cell concentration of 10,490 cells per cu. mm. than that of Angus females ($P < 0.05$). In the David line, males with a cell count of 7,970 cells

Table 4. Average Total Red Cell Count and Mean Corpuscular Volume at 500 and 800 Pounds Body Weight

Group	Red cell count				Mean corpuscular volume			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	Millions/ cu. mm.	*Millions/ cu. mm.*	*Millions/ cu. mm.*	*Millions/ cu. mm.*	*cubic microns*	*cubic microns*	*cubic microns*	*cubic microns*
Lionheart males	7.54	(6.32-9.03)	8.13	(6.64-9.13	53.7	(45.4-58.6)	11.1	(44.3-64.8)
Lionheart females	8.80		8.78		45.5		43.9	
Prince males	7.32	(6.04-8.44)	7.76	(6.16-8.90)	52.2	(48.2-59.3)	53.6	(41.9-65.5)
Prince females	7.54	(6.88-9.20)	8.09	(7.06-9.54)	57.9	(47.6-65.8)	53.4	(46.0-63.2)
David males	7.00	(5.82-7.64)	7.97	(7.20-9.10)	53.6	(49.3-58.4)	52.8	(46.8-55.6)
David females	8.17	(6.25-9.60)	8.05	(6.91-8.87)	49.5	(44.4-61.1)	57.0	(51.4-67.3)
Hereford males	7.29	(5.82-9.03)	7.96	(6.16-9.13)	53.2	(45.4-59.3)	53.5	(41.9-65.5)
Hereford females	7.91	(6.25-9.60)	8.13	(6.91-9.54)	53.4	(44.4-65.8)	54.1	(43.9-67.3)
Angus males	8.25	(7.77-9.81)	8.51	(7.28-9.39)	50.8	(47.4-53.9)	55.2	(49.4-59.8)
Angus females	7.76	(6.32-9.46)	8.62	(7.14-9.47)	51.9	(43.9-58.6)	52.8	(42.4-66.9)
All males	7.53	(5.82-9.81)	8.10	(6.16-9.39)	52.6	(45.4-59.3)	53.9	(41.9-65.5)
All females	7.83	(6.25-9.60)	8.38	(6.91-9.54)	52.7	(43.9-65.8)	53.5	(42.4-67.3)
All animals	7.70	(5.82-9.81)	8.25	(6.16-9.54)	52.6	(43.9-65.8)	53.7	(41.9-67.3)
Standard error of the mean for all animals	±.15		±.12		±.78		±1.00	

Table 5. Mean Corpuscular Hemoglobin and Mean Corpuscular Hemoglobin Levels at 500 and 800 Pounds Body Weight

Group	Mean corpuscular hemoglobin				Mean corpuscular hemoglobin concentration			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	micro-micrograms	*micro-micrograms*	*micro-micrograms*	*micro-micrograms*	*percent*	*percent*	*percent*	*percent*
Lionheart males	15.3	(12.6-17.9)	16.1	(13.8-17.5)	28.6	(22.8-31.9)	30.1	(26.6-35.1)
Lionheart females	14.4		14.9		31.7		34.0	
Prince males	15.7	(14.3-17.9)	16.8	(14.2-20.9)	30.1	(26.9-32.9)	31.5	(28.2-33.8)
Prince females	16.6	(14.1-19.7)	16.3	(13.4-19.1)	28.7	(25.4-33.1)	30.7	(25.6-33.8)
David males	16.3	(15.5-17.0)	15.5	(12.2-17.9)	30.4	(28.1-34.2)	30.6	(28.3-34.6)
David females	15.5	(13.8-16.9)	16.3	(15.0-17.1)	31.5	(23.9-38.2)	28.6	(25.4-30.9)
Hereford males	15.8	(12.6-17.9)	16.2	(12.2-20.9)	29.7	(22.8-34.2)	30.7	(26.6-35.1)
Hereford females	15.9	(13.8-19.7)	16.2	(13.4-19.1)	30.1	(23.9-38.2)	30.1	(25.4-34.0)
Angus males	15.4	(13.9-16.2)	16.1	(14.6-18.3)	30.4	(28.1-32.9)	29.3	(26.1-32.7)
Angus females	16.1	(13.0-18.3)	15.8	(14.1-18.1)	31.2	(27.0-37.7)	30.3	(26.7-36.1)
All males	15.7	(12.6-17.9)	16.1	(12.2-20.9)	29.9	(22.8-34.2)	30.4	(26.1-35.1)
All females	16.0	(13.0-19.7)	16.0	(13.4-19.1)	30.6	(23.9-38.2)	30.2	(25.4-36.1)
All animals	15.9	(12.6-19.7)	16.1	(12.2-20.9)	30.3	(22.8-38.2)	30.3	(25.4-36.1)
Standard error of the mean for all animals	±0.23		±0.25		±0.46		±0.43	

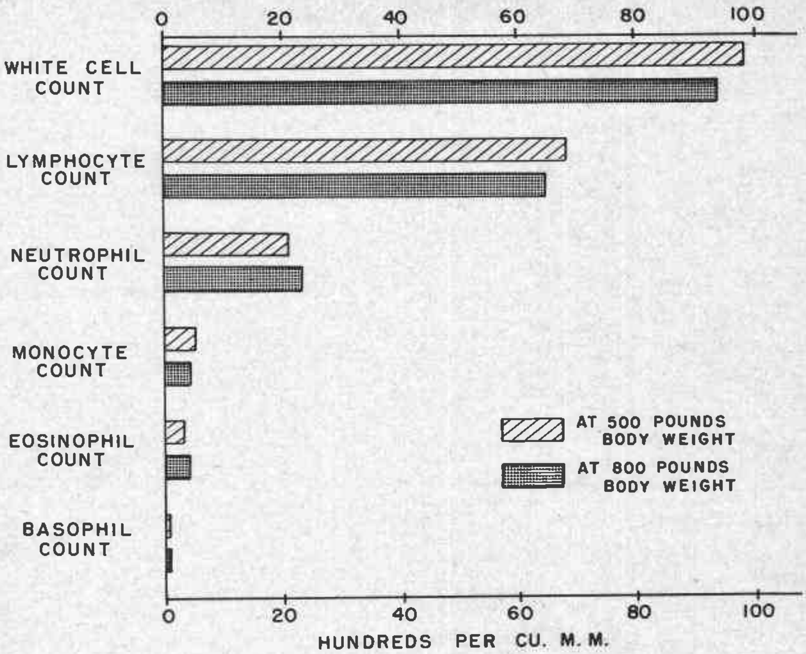

Figure 1. Histogram of the Average Leucocyte Counts of the Calves.

per cu. mm. had a significantly lower cell concentration than females ($P < 0.01$).

In comparisons between breeds and lines, only in the case of Prince and David females was any difference found (Table 7). Prince females had a level of 8,270 cells per cu. mm. which was significantly lower than the white cell concentration of 11,440 per cu. mm. of David females.

Lymphocyte Count

At 500 pounds body weight, the calves averaged 6,820 cells per cu. mm. lymphocytes. Angus males with a lymphocyte count of 7,160 cells per cu. mm. had a significantly higher count than Angus females ($P < 0.05$). No other sex or line differences were found.

At 800 pounds body weight, the average lymphocyte count for all calves was 6,520 cells per cu. mm. (Table 6). No sex or line differences were found at this weight (Table 7).

Other White Cell Types

No sex or line differences were determined for the polymorphonuclear neutrophils, monocytes, eosinophils, or basophils. However,

Table 6. Average Total White Cell Count and Average Lymphocyte Count at 500 and 800 Pounds Body Weight

Group	White cell count				Lymphocyte count			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	100/cu. mm.	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*
Lionheart males	103.6	(92.0-120.0)	97.2	(62.0-114.0)	78.0	(68.6- 77.0)	62.7	(47.1- 75.7)
Lionheart females	90.0		97.4		81.0		58.4	
Prince males	84.0	(66.0- 94.0)	90.2	(74.0-109.0)	63.9	(46.2- 77.1)	63.4	(44.5-95.9)
Prince females	100.3	(82.0-130.0)	82.7	(54.0-114.0)	67.2	(47.0- 97.6)	57.1	(41.6-82.6)
David males	102.8	(94.0-122.0)	79.7	(72.0- 91.0)	76.9	(61.7-100.0)	78.1	(69.8-84.3)
David females	97.2	(78.0-118.0)	114.4	(92.0-138.0)	71.1	(61.6- 84.8)	83.3	(72.7-93.0)
Hereford males	96.8	(66.0-122.0)	89.0	(62.0-114.0)	72.9	(46.2-100.0)	68.1	(44.5-95.9)
Hereford females	98.2	(78.0-130.0)	97.1	(54.0-138.0)	70.0	(47.0- 97.6)	68.1	(41.6-93.0)
Angus males	113.2	(90.0-130.0)	104.9	(89.0-142.6)	71.6	(54.1-100.8)	64.4	(46.6-87.0)
Angus females	94.8	(78.0-106.0)	92.8	(72.0-112.0)	59.0	(51.5- 75.5)	59.1	(37.8-76.2)
All males	100.9	(66.0-130.0)	93.0	(62.0-142.6)	72.6	(46.2-100.8)	67.2	(44.5-95.9)
All females	96.5	(78.0-130.0)	95.0	(54.0-138.0)	64.5	(47.0- 97.6)	63.6	(37.8-93.0)
All animals	98.5	(66.0-130.0)	94.1	(54.0-142.6)	68.2	(46.2-100.8)	65.2	(37.8-95.9)
Standard error of the mean for all animals	±2.18		±2.89		±2.23		±2.36	

Table 7. AVERAGE NEUTROPHIL COUNT AND AVERAGE MONOCYTE COUNT AT 500 AND 800 POUNDS BODY WEIGHT

Group	Neutrophil count				Monocyte count			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	100/cu. mm.	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*
Lionheart males	18.1	(10.1-23.9)	26.0	(8.7-59.3)	5.5	(0.0- 9.6)	5.6	(0.0-10.7)
Lionheart females	3.6		30.2		1.8		4.9	
Prince males	12.0	(7.5-13.9)	19.5	(8.7-37.4)	5.8	(2.8- 7.5)	4.3	(2.2- 6.7)
Prince females	21.2	(11.5-33.8)	15.5	(2.7-36.5)	6.1	(3.3-10.6)	6.9	(3.2-10.3)
David males	19.0	(7.0-30.4)	22.4	(16.4-28.3)	5.0	(1.9-12.2)	7.5	(2.1-12.4)
David females	16.4	(4.7-30.7)	22.2	(14.7-31.4)	6.9	(3.1- 8.8)	5.4	(2.8- 8.3)
Hereford males	16.4	(7.0-31.4)	22.6	(8.7-59.3)	5.4	(0.0-12.2)	5.8	(0.0-12.4)
Hereford females	17.7	(3.6-33.8)	19.5	(2.7-36.5)	6.1	(1.8-10.6)	6.1	(2.8-10.3)
Angus males	30.0	(6.0-47.1)	28.7	(10.7-42.7)	7.6	(3.6- 9.1)	6.2	(2.9-12.7)
Angus females	27.6	(19.1-42.3)	25.4	(6.5-42.3)	5.0	(1.0-10.3)	4.4	(0.0-13.0)
All males	19.7	(6.0-47.1)	24.1	(8.7-59.3)	5.0	(0.0-12.2)	5.9	(0.0-12.7)
All females	22.6	(3.6-42.3)	22.5	(2.7-42.3)	5.5	(1.0-10.6)	5.3	(0.0-13.0)
All animals	21.3	(3.6-47.1)	23.2	(2.7-59.3)	5.7	(0.0-12.2)	4.0	(0.0-13.0)
Standard error of the mean for all animals	±1.67		±1.82		±0.44		±0.51	

Table 8. Average Eosinophil Count and Average Basophil Count at 500 and 800 Pounds Body Weight

Group	Eosinophil count				Basophil count			
	At 500 pounds		At 800 pounds		At 500 pounds		At 800 pounds	
	Average	Range	Average	Range	Average	Range	Average	Range
	100/cu. mm.	*100/cu. mm.*	*100/cu. mm.*	*100/cu. mm.*	*cells/cu. mm.*	*cells/cu. mm.*	*cells/cu. mm.*	*cells/cu. mm.*
Lionheart males	2.2	(0.0- 5.2)	2.8	(0.9- 3.4)	0	(0-0)	41	(0.0-114)
Lionheart females	2.7		3.9		90		0	
Prince males	2.1	(0.7- 4.6)	2.7	(0.0- 4.5)	18	(0.0- 92)	30	(0.0- 74)
Prince females	6.3	(3.3-10.4)	3.1	(0.0- 6.7)	0	(0-0)	12	(0.0- 73)
David males	2.2	(1.2- 3.8)	6.5	(0.0-14.2)	19	(0.0- 94)	21	(0.0-106)
David females	2.1	(1.1- 2.9)	2.9	(0.0- 5.5)	58	(0.0-106)	58	(0.0-184)
Hereford males	2.2	(0.0- 5.2)	4.0	(0.0-14.2)	12	(0.0- 94)	30	(0.0-114)
Hereford females	4.3	(1.1-10.4)	3.1	(0.0- 6.7)	32	(0.0-106)	47	(0.0-184)
Angus males	3.7	(2.0- 5.4)	5.4	(2.1-10.0)	77	(0.0-204)	29	(0.0-143)
Angus females	3.1	(0.0-12.7)	4.4	(0.0-11.2)	32	(0.0-204)	46	(0.0-318)
All males	2.6	(0.0- 5.4)	4.3	(0.0-14.2)	29	(0.0-204)	30	(0.0-143)
All females	3.7	(0.0-12.7)	3.7	(0.0-11.2)	32	(0.0-204)	47	(0.0-318)
All animals	3.2	(0.0-12.7)	4.0	(0.0-14.2)	30	(0.0-204)	39	(0.0-318)

Table 9. CORRELATION COEFFICIENTS INVOLVING RATE OF GAIN, FEED PER UNIT GAIN, AGE AT 500 POUNDS, AND THE CELLULAR BLOOD CONSTITUENTS AT 500 AND 800 POUNDS BODY WEIGHT

	Rate of gain	Feed per unit gain	Age at 500 pounds	500 pound vs. 800 pound data
Hemoglobin				
at 500 pounds	—.46**	.41**	.06	.35*
at 800 pounds	—.29*	.33*	.13	
Hematocrit				
at 500 pounds	—.08	.12	.27	.19
at 800 pounds	—.17	.23	—.05	
Red cell count				
at 500 pounds	—.29*	.22	.15	.33*
at 800 pounds	—.20	.23	.01	
Mean corpuscular volume				
at 500 pounds	.21	—.10	.16	.15
at 800 pounds	.03	0	—.17	
Mean corpuscular hemoglobin				
at 500 pounds	—.01	.05	—.10	.04
at 800 pounds	—.01	.01	—.05	
Mean corpuscular Hb concentration				
at 500 pounds	—.25	.17	—.22	.14
at 800 pounds	0	0	.14	
White cell count				
at 500 pounds	.10	—.15	—.28	.17
at 800 pounds	—.20	.13	.11	
Lymphocyte count				
at 500 pounds	.29*	—.38**	—.15	.02
at 800 pounds	.03	.15	0	
Neutrophil count				
at 500 pounds	—.22	.09	.07	.35*
at 800 pounds	—.07	.19	.07	

** Significant at the 1% level
* Significant at the 5% level

the means and ranges for lines and sexes in these white cell types are presented in Tables 7 and 8.

Correlations Between Feed Lot Performance and Blood Constituents

In order to determine whether any relationships exist between blood constituents and feedlot performance data, correlations were calculated and are presented in Table 9.

Blood hemoglobin was inversely related to rate of gain at 500 and 800 pounds body weight. The correlation coefficient of —.46 at

500 pounds body weight was significant at the 1% level, while at 800 pounds body weight the correlation was significant at the 5% level. Blood hemoglobin was also positively correlated with feed consumption per unit gain with correlation coefficients of similar order to those with rate of gain.

No significant correlations were recorded between hematocrit and performance characteristics although the correlation of .27 with age at 500 pounds body weight approached significance.

Red cell count at 500 pounds body weight was inversely and significantly related to rate of gain ($r = -.29$), but no other significant correlations were determined between this constituent and the performance data.

The only other blood constituent to show significant correlations with the performance data was the lymphocyte count at 500 pounds body weight. It was positively related to rate of gain ($r = .29$) and inversely related to feed consumption per unit gain ($r = -.38$). Both correlations were significant at the 5% level (Table 9).

Correlations Between the Blood Constituents

Correlations between the 500 and 800 pound data were examined for the blood constituents (Table 9) to give some estimate of the repeatability of determinations from one weight to the other. Blood hemoglobin, red cell count, and neutrophil count all showed correlations which were significant at the 5% level.

Discussion

In this study, in addition to examining the blood constituents from the standpoint of similarities and differences between sexes and breeds and of general changes with growth, the particular relationship these blood constituents bear to rate and economy of gain will be discussed.

Red Cell Components

Since all red cell characteristics are interrelated they will be discussed together. It can be seen by reference to the literature reviewed, that all data obtained in this study lie in the normal range. Of all the characters of the red cell studied, the hemoglobin level shows most sex differences and then only at 500 pounds body weight. The males had significantly lower levels than the females. Similarly, when only Herefords were considered, males had significantly lower levels than females. There was also an increase in the hemoglobin level of all calves at 800 pounds over the level of those at 500 pounds body weight. This is at variance with the findings of MacDonald and coworkers (1956) who found no change in the hemoglobin level at 500 and 800 pounds body weight in calves during 1953. This variation may be due to seasonal effects. Also it may in part be conditioned by weaning calves from a diet containing some milk low in iron and offering a dry diet relatively high in iron.

In the hematocrits studied, only Prince male calves had significantly lower levels than Prince females at 500 pounds body weight. At 800 pounds body weight, David males had lower levels than David females. No other sex differences were found in red cell characteristics. It is desirable to note that these hematocrit values were obtained using the International No. 2 centrifuge at 3,000 revolutions per minute as recommended by Coffin (1954). The values obtained for hematocrit agree well with the literature studied and the derived values of mean corpuscular volume; hemoglobin and hemoglobin concentration compare quite closely with those quoted by Coffin (1954), Albritton (1952), and Greatorex (1954).

Very few line differences were found in red cell data. At 500 pounds body weight Hereford males were found to have significantly lower hemoglobin levels than Angus males. At 800 pounds body weight Hereford males had a significantly lower hematocrit reading than Angus males.

Repeatability of levels from 500 to 800 pounds body weight was generally low, and significant correlations between 500 and 800 pound levels were recorded only for hemoglobin levels and red cell counts.

White Cell Components

The only white cell components considered from the viewpoint of sex and line variation are total white cell count and lymphocyte count. Significant sex differences in white cell components at 500 pounds body weight were observed between all males and females and Angus males and females. The lymphocyte count of Angus males at 500 pounds body weight was also significantly higher than that of Angus females. At 800 pounds body weight, Angus males again had higher total white cell counts than Angus females. The David males at 800 pounds body weight had significantly lower levels than David females.

A number of line differences were observed in the total white cell count. At 500 pounds body weight Angus males had higher levels than Hereford males and males in Lionheart and David lines had higher levels than Prince males. At 800 pounds, the only line difference occurred where David females had a significantly higher level than Prince females.

Changes in Relation to Growth

In general, blood hemoglobin, hematocrit, and red cell count increased from 500 to 800 pounds body weight. In every group studied blood hemoglobin rose with age. Only in isolated instances of the Lionheart female and the Prince line was the trend contrary for blood hematocrit. In a few cases in red cell count, there was little change with age, but in most cases there was an appreciable increase with age.

It is remarkable to note that the mean corpuscular volume, hemoglobin, and hemoglobin concentration levels for all animals are quite consistent at the two weights. This confirms the constancy of red cell size and that changes in hemoglobin, hematocrit, and red cell count are all due to lower concentration of cells in younger and lighter animals (Figure 2).

With age there is a decrease in white cell count which is paralleled by a similar decrease in lymphocyte count. This is not unexpected because lymphocytes constitute the major cell type in the total white cell count. The monocyte count also is reduced in older animals but neutrophil, eosinophil, and basophil counts are increased with age. Some of the significance of this increase in neutrophil count is lost, however, when one considers the increased variation in neutrophil levels at 800 pounds body weight over that at 500 pounds body weight (Table 7).

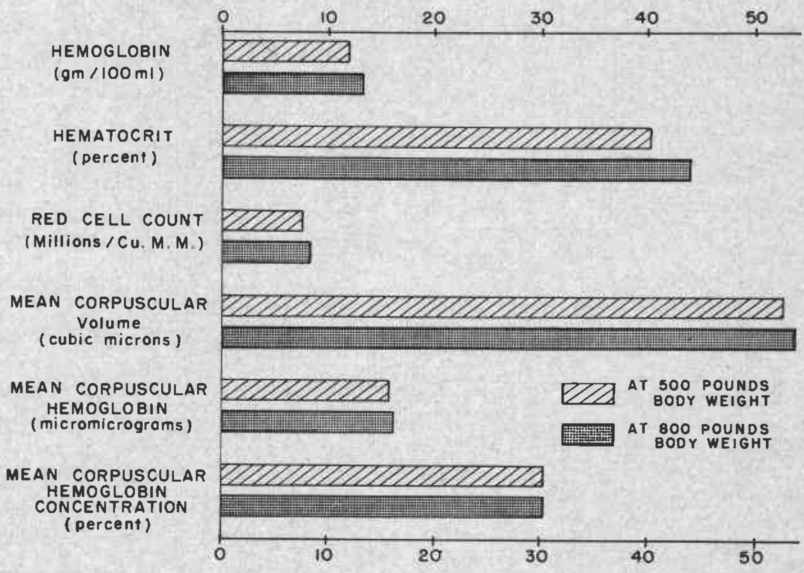

Figure 2. Histogram of the Red Cell Characteristics of the Calves.

Relationship with Performance Characteristics

Of all blood cellular constituents studied, hemoglobin level was the only one to give correlations with rate of gain and feed consumption per unit gain at both 500 and 800 pounds body weight. Hemoglobin level was inversely related to rate of gain. This at first seems to be a rather erroneous relationship implying that the lower the hemoglobin level, the faster the rate of gain. This relationship, however, is produced by the increase in hemoglobin level with age so that the younger animals at 500 and 800 pounds, which were also the more rapidly gaining animals, had the lower hemoglobin levels. The negative correlations between red cell count and rate of gain can also be explained on the same basis.

The lymphocyte count at 500 pounds body weight was positively related to rate of gain. This relationship could possibly be explained by the fact that in faster growing animals lymphocyte production parallels general tissue cell production. The function of lymphocytes has not as yet been clarified, but appears to be related to production of plasma proteins. The lack of relationship of the other leucocytes is understandable since their functions are largely phagocytic.

It appears evident that the relationship between cellular constituents of blood and rate or economy of gains is not striking, and the ones that exist probably are due to age effects in this group of normal animals. It is quite possible, however, that disease conditions decreasing red cell number or hemoglobin concentration, or increasing white cell numbers might be associated with lower rate and economy of gains.

General Considerations

Constancy of average values for mean corpuscular hemoglobin, mean corpuscular volume, and mean corpuscular hemoglobin concentration of all animals at the two weights studied illustrates the value of these as indicators of anaemias. Determinations of hemoglobin, hematocrit, and red cell count are subject to such considerable normal variation that they would not, in themselves, provide as sensitive an indication of anaemia as these values which are derived from them.

Summary and Conclusions

1. Sex, breed, and line differences for cellular constituents of the blood of 45 Hereford and Angus male and female calves on performance test from 500 to 800 pounds body weight have been considered.

2. Normal values are presented for hemoglobin, hematocrit, red cell count, mean corpuscular volume, mean corpuscular hemoglobin,

mean corpuscular hemoglobin concentration, white cell count, lymphocyte, neutrophil, monocyte, eosinophil, and basophil counts. Normal beef calves exhibited wide variations in concentration of the blood constituents studied at both 500 and 800 pounds body weight.

3. Average hemoglobin level for all male calves at 500 pounds body weight was lower than the average for female calves. Hereford males also had lower levels than both Hereford females and Angus males.

4. Prince line male calves had lower hematocrit percentages than Prince females at 500 pounds body weight. At 800 pounds body weight, David males had lower levels than David females.

5. Male calves had a higher average white cell count than females at 500 pounds body weight. Angus males also had significantly higher white cell counts than either Angus females or Hereford males. Within the Hereford lines both Lionheart and David males had higher white cell counts than Prince males. At 800 pounds body weight, Angus males again had higher levels than Angus females. Within the Hereford lines, David males had higher white cell counts than David females and David females had higher counts than Prince females.

6. Hemoglobin concentration at both 500 and 800 pounds body weight was inversely related to rate of gain, and positively related to feed consumption per unit of gain. At 500 pounds body weight, red cell count had an inverse relationship and lymphocyte count had a positive relationship to rate of gain.

7. The hemoglobin level, red cell count, and neutrophil count at 500 pounds body weight were significantly correlated to values for the corresponding constituent at 800 pounds body weight.

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